THE ENGINEER

AUGUST 29, 1952

The Radio Show

THE nineteenth National Radio and Television Exhibition organised by the Radio Industry Council was opened at Earl's Court by Lord Burghley, President of the Council, on Wednesday, August 27th. The show is open to the public every weekday from 11 a.m. to 10 p.m. until Saturday, September 6th. There are a total of 108 exhibitors, of whom thirty-two are manufacturers of radio and television receivers. Apart from these commercial receivers there a number of exhibits displayed by the R.I.C., in association with many of its member firms, to exemplify the part played by electronics in science and industry. One of the demonstrations shows the apparatus used for underwater television and the results that can be achieved in a tank under conditions corresponding as far as possible to those met on the ocean bed. Another demonstration illustrates the remote control of model ships by radio. One of the many applications of radio-frequency heating—the hardening of steel—is shown with the help of a 7kW radio-frequency generator. Visitors to Earl's Court can also see an interesting aircraft instrument, a frequency-modulated radio altimeter which operates in the 4200–4400 Mc/s band. It gives the pilot a direct indication of the height of the aircraft above ground, the readings being independent of barometric pressure variations and the height of the ground above sea level. Two height ranges are included, one dial reading 0ft to 500ft and the other 0ft to 5000ft. The first scale is calibrated logarithmically so that, as the aircraft descends its distance from the ground can be read with increasing accuracy. The use of suppressed aerials avoids any protrusion from the skin of the fuselage. In a group of exhibits by the Regular Army, the Royal Electrical and Mechanical Engineers show a guided missile and demonstrate radar and predictors on a model gun site, and the Royal Corps of Signals show some modern wireless equipment and a chart of the Army's communications network covering the Commonwealth and Empire. A series of exhibits by the Royal Navy show some of the many naval uses of electronics and radio, including a twin Bofors gun mounting and the separate director site from which the gun can be directed through a small hand control operating through the medium of an electronic amplifier. On the same stand visitors can also see a reproduction of a submarine radar and wireless office manned by naval ratings, a simple electronic computer of the kind used in naval gunnery tables, and an oscilloscope which illustrates the possibilities of three-dimensional scanning. Among the many interesting exhibits to be seen working on the Royal Air Force stand are a radio-controlled model aircraft, an "A1" scanner, a Gee Mark III and a radio compass.

Development of Natural Resources of Newfoundland and Labrador

LAST week Mr. Joseph Smallwood, the Prime Minister of Newfoundland, who is in this country to discuss plans for the development of the natural resources of Newfoundland and Labrador, addressed a meeting of firms and associations likely to be interested in this development. The meeting was arranged by the Federation of British Industries. Mr. Smallwood suggested the formation of a new British company, made up of a number of existing companies, to develop the resources of Newfoundland and, more particularly, Labrador. The actual development of the resources believed to exist in Labrador must, he said, be preceded by a prospecting or exploratory period. Among the minerals known to exist there were vast quantities of iron ore, together with manganese, and, also, there was every reason to suppose, titanium, copper, lead and zinc. There were unlimited quantities of high-grade timber and a greater hydro-electric potential than was at present developed in all Canada. In pointing out that Labrador was the great remaining storehouse of natural wealth and natural resources of North America, Mr. Smallwood said Britain possessed the greatest experience and skill in developing remote, difficult and uninviting areas, and his Government wanted Labrador to be developed by British companies. The cost would be stupendous, and he estimated that if a new British company were formed to explore and develop the natural resources of Labrador, a capital of £2 million would be needed. By using British personnel and equipment, including British aircraft for the preliminary aerial survey, a relatively small part of the £2 million need be converted into dollars. Development, as distinct from prospecting, would have no time limit set to it, and its cost might be anything from 20 to 100 million dollars. Mr. Smallwood described how, in the preparations for the development of the vast iron ore deposits in the west of Labrador, the building of the railway to it had to be carried out by aerial survey and by "flying in" the necessary construction equipment. The 365-mile railway was being constructed at a cost of 150 million dollars.

Lynmouth Power Station

IT is learned from the South-Western Electricity Board that emergency supplies of electricity were made available to all consumers in Lynton on Thursday, August 21st. Plans have also been prepared for the establishment of a new power system side by side with the reconstruction of the district. Up to the time of the recent floods Lynmouth and most of Lynton were supplied from the generating station at Lynmouth, which, it may be recalled, was the only station generating at the non-standard frequency of 100 c/s. Lynmouth power station was regarded as being the second hydro-electric plant established in this country : a supply was first given in April, 1890, when a 150 h.p. turbine was operated by water taken from the East Lyn River through 500 yards of open leat and 500 yards of 30in diameter cast iron pipe-line. Initially, the supply was solely for lighting ; accordingly, the plant was run from dusk until midnight, and, during the winter, from 6 a.m. to "good daylight." By 1896 the lighting peak load created a serious probem—accentuated by a mill a few miles upstream which interrupted the supply of water when demand was heaviest. It was therefore decided to construct a high-level reservoir, with a capacity of 32,000 cubic feet, at the top of an adjoining hill, and 500 yards of 6in diameter cast iron pipe-line were laid down the hillside to the generating station. When the electrical demand was low, surplus energy was used to pump water to the storage reservoir : when the demand rose, water from the reservoir provided a high-pressure supply to operate a 50 h.p. Pelton wheel set installed to carry peak loads. More efficient turbines installed in 1904 and 1911 coped with the demand from consumers at Lynton and Lynmouth until 1921, when they were supplemented by the first two of a series of oil engines. About a year ago a scheme was started, as part of the South-Western Electricity Board's development plan, to supply the district at standard voltage and frequency. A new 33kV line, at present operating at 11kV, was built from Barnstaple to Lynton and part of Lynton had been changed over to the new supply before the recent floods. Extensive damage was done by the flood to the buildings and plant at Lynmouth generating station, and a section of the leat carrying water to the turbines was destroyed. To give emergency supplies the new line from Barnstaple was connected with the old 100 c/s underground cable system in Lynton, and consumers' appliances were changed to suit the new 50 c/s supply. The Board has now decided to extend the new line from Lynton into Lynmouth as the task of road reconstruction and rebuilding proceeds.

Fuel Efficiency Course

THE Eastern Region of the Fuel Engineering Advisory Service of the Ministry of Fuel and Power has organised a Works' Engineers' Refresher Course to be held at the University of Cambridge Engineering Laboratory, Trumpington Street, from Monday, September 22, to Friday, September 26, 1952. The object of the course is to provide an opportunity for works' engineers and others to obtain up-to-date information on the general and specific aspects of the efficient use of heat and power, so that the standard of fuel efficiency, with regard to the consumption of coal and oil fuel, may be maintained and, if possible, improved. On Monday, following an opening address by Mr. W. W. S. Robertson, the chairman of the Eastern Regional Fuel Efficiency Committee, two lectures entitled "Boiler Plant and its Operation" and "Steam Utilisation," will be given. The titles of the lectures to be read on Tuesday are : "Possibilities of Self-Generation of Electricity and Use of Exhaust Steam," "Utilisation of Electricity" and the "Utilisation of Gas." On the next day, three more lectures will be delivered, namely, "The Economical Use of Compressed Air," "Refrigeration Plant" and "The Application of Gas Turbines to Industry," while on Thursday only two are to be given under the titles "Heating, Hot Water Supply and Ventilation" and "Structural and Thermal Insulation." Two lectures will be given on Friday, the closing day, "Boiler Plant Instrumentation" and "Boiler Feed Water Treatment" and will be followed by a closing address by W. R. Hawthorne, Professor of Applied Thermodynamics at the University. All inquiries regarding the course may be obtained from the Ministry of Fuel and Power, Brooklands Avenue, Cambridge.

International Congress of Bridge and Structural Engineering

THE International Association for Bridge and Structural Engineering opened its fourth congress on Monday last in Cambridge. During this week, papers covering an extremely wide range of the problems encountered in structural engineering are being presented for discussion. Next week the headquarters of the congress will be moved to London, and various visits to research stations, works and other places of interest will take place, together with other social events. Over 600 members are attending the congress, and the various papers have been prepared by authors from a number of countries. The papers are grouped under the following general heads :—general questions, the bases of calculation and the safety of structures ; the development of methods of calculation ; metal structures—their fundamental principles ; practical applications in the design of metal structures ; concrete and reinforced concrete structures ; and current problems of concrete and reinforced concrete, including prestressed concrete. The opening session of the congress took place in the Senate House at Cambridge ; the president of the congress is Lord Woolton, Lord President of the Council, who received the honorary degree of LL.D. before the opening session.

The Gas Turbine in Relation to Fuel Economy

The necessity of obtaining maximum economy in the utilisation of fuel has prompted the writing of this article by Dr. Karrer, of Ateliers de Construction Oerlikon, of Zurich, with a short introduction by the staff of Power Jets (Research and Development), Ltd. The article describes several methods of combining gas turbine and steam cycles in a single installation. These combinations either use the exhaust gases of the gas turbine as combustion air in the steam boiler, or, alternatively, employ the boiler flue gases in a heat exchanger to heat or partially heat the gas turbine fluid.*

Introduction

GAS turbines in various forms have been in service for many years. Until fairly recently, their main use was as auxiliaries, generally serving to increase output by turbo-supercharging. Examples of this class are turbo-supercharged reciprocating engines (first used over thirty years ago), Velox boilers and Houdry plant used in oil refineries to regenerate catalyst beds, simultaneously converting some of the heat generated to power.

The phenomenal success of the aero engine gas turbine has led to a great expansion in the work being done on all other kinds of gas turbines, especially, of course, the normal fuel-burning plants for the generation of power. While they can, in many instances, stand on their own feet as prime movers, they can be combined in various ways, often with great advantage, with steam cycles. Some of them are dealt with in detail by Dr. Karrer in the remaining sections of this article.

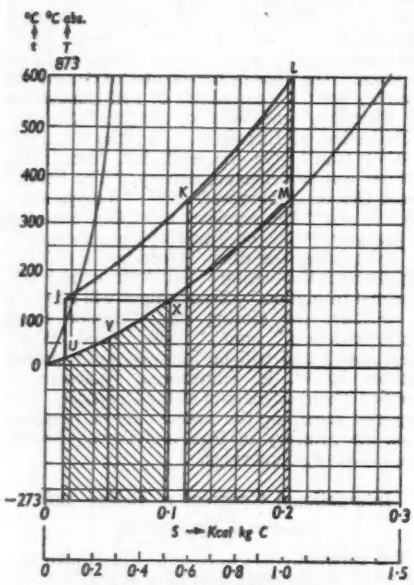


Fig. 1—Entropy Diagram

While such combined gas and steam cycles offer the most marked and widely applicable contribution which the gas turbine can make to fuel economy, there are various other ways in which it can be of assistance in this vital problem.

For instance, by the incorporation of a more or less advanced type of gas turbine blowing plant, the gas consumption of a blast-furnace can be greatly reduced, thus freeing valuable fuel for other uses. Similarly, in nitric acid manufacture, the waste heat can be utilised via a gas turbine to make the plant self-supporting, or nearly so. Oxygen separation plants can be made to use less power by incorporating better compressors and expanders, derived from gas turbine techniques.

Then there is the whole range of processes, including space heating, air conditioning and drying. Here, the gas turbine can help to effect very large fuel economies, either by the use of its own exhaust heat, or by using efficient components in heat pumps, pressure stills and the like.

In addition, there are the heat sources which can be used by the gas turbine more conveniently and more efficiently than by other means. They include peat, methane gas from sewage works, waste heat from gas works and steel furnaces and probably many others.

Although there is not space to go into details of any of these applications here, it can be seen that far from being extravagant in its use of fuel, the gas turbine, properly incorporated as part of a larger scheme, can reduce the consumption of fuel and of power very considerably. While few of the basic ideas mentioned are new, the detailed studies which have recently been carried out in increasing numbers, together with the development of many successful industrial gas turbines in recent years, will undoubtedly lead to the adoption of a large proportion of these and other schemes in the next few years.

Combined Steam and Gas Plant

The steam turbine, whether as a condensing or back-pressure machine, or as the combination of pass-out and condensing, dominates the two fields of production of power alone and of power coupled with steam for heating. The gas turbine has hitherto been regarded as a power producer only for obtaining higher efficiencies with less consumption of cooling water and quicker service availability.

It will be shown that the gas turbine can be used both to supplement power production from a boiler plant and to supply heat as well as power.

For the waste gases of a gas turbine contain a considerable amount of heat, even if there is provided a heat exchanger in which the greatest possible quantity of heat of the turbine outlet gases is recuperated by being transmitted to the compressed air of the plant.

Fig. 1 represents the theoretical diagram of entropy (without losses and without heat-transfer temperature drop) of a simple open-cycle gas turbine plant. A compressor inlet temperature of 15 deg. Cent. and a turbine inlet temperature of 600 deg. Cent. is assumed. *U J* represents the adiabatic compression; *J K* the preheating under constant pressure; *K L* the heating by combustion again under constant pressure (the area below *K L*, cross-hatched, gives the amount of heat introduced by the fuel); *L M* expansion in the turbine; *M X* cooling of the outlet gases by giving up a part of their waste heat to the compressed air for preheating it from point *J* to point *K*; finally the area below *X U* (cross-hatched) represents the amount of heat which the gases leaving the heat exchanger still contain as lost heat. Comparing this area with the area of combustion heat, one realises that even in the case of an infinitely big heat exchanger (no temperature difference between point *X* and point *J*) the amount of heat lost in the chimney is about half the amount of combustion heat. Even if higher temperatures are assumed at the turbine inlet, and even if other means for increasing the plant efficiency are provided (reheat, compressor inter-cooling, &c.), the heat lost in the chimney will always represent the biggest amount of lost energy of a gas turbine plant.

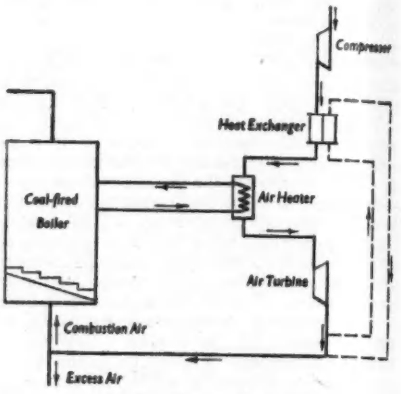


Fig. 2—"Steam-Air" Plant

On the other hand, the temperature at which this heat is available is generally too low to utilise these waste gases by heat transfer for useful purposes.

There is, however, one way in which to recover the waste heat *U X* without being obliged to use it at the corresponding low temperatures, namely, superposing a second cycle above the gas turbine cycle and employing the waste gases as combustion air in the second cycle.

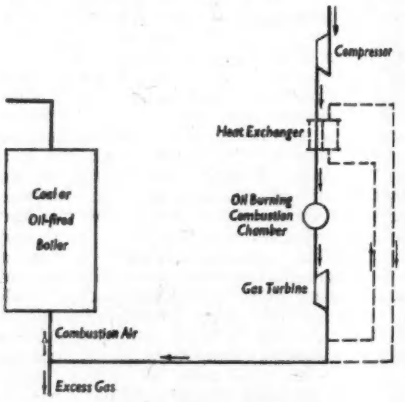


Fig. 3—"Steam-Gas" Plant

The utilisation of the waste gases of a gas turbine plant (as combustion air in a second cycle) is possible without difficulty because these gases are rich in oxygen. The combustion in the gas turbine combustion chamber takes place at a very high excess of air, i.e. about five times the stoichiometric air quantity or more. In the case where the gas turbine air is heated indirectly in an air heater instead of being burnt in a combustion chamber, the air excess will even be infinite. In any case, the combustion in the second cycle will be as good as any combustion in classic cycles, and this has been proved in the

* The Oerlikon company is licensee under Swiss patents owned by Power Jets (Research & Development) Ltd., whilst the latter company negotiates licences under gas turbine patents held by the Swiss company.

gas turbine combined boiler of the Oerlikon experimental plant.

The second cycle may be represented by any heat or power plant containing a furnace, especially by steam cycles with boilers, for instance, of back-pressure or condensing plants.

Figs. 2 and 3 show two principal circuits of combustion.

Fig. 3 represents a gas turbine plant with its own combustion chamber (" steam-gas plant"). Fig. 2 shows a combination where the gas turbine fluid is heated by heat exchange through the combustion gases of the second cycle, i.e. through the combustion gases of the boiler (" steam-air plants ").

In both cases the waste heat of the gas turbine plant may be entirely recuperated, if the amount of combustion air of the boiler is equal to the quantity of waste gases of the gas turbine plant. In this case, the output of the gas turbine is theoretically produced with an efficiency of 100 per cent, if owing to this combination no additional losses occur in the boiler cycle. Such additional losses may, however, influence the efficiency of the combination, especially due to an increase of the outlet temperature of the waste gases of the boiler. It can, however, be shown that in all cases of combustion the additional losses occurring in the second cycle are smaller than the gain on the gas turbine side, so that a higher overall efficiency of the combined plant can always be obtained.

The following examples illustrate different possible combinations. In each case only one of the two principal circuits of Figs. 2 and 3 will be described. It may, however, be kept in mind that all examples can also be executed using the other circuit. The special advantages of the " steam-gas plant " (according to Fig. 3) are simplicity, cheaper price and possible independent regulation of both parts of the combination. The advantage of the " steam-air plant," according to Fig. 2, lies in the possibility of burning coal as the sole fuel of the whole plant, whilst in the gas turbine part of Fig. 3, the combustion of solid fuels is still being developed. As soon as coal burning in gas turbine plants is possible, the steam-gas cycle may have preference over the steam-air cycle, owing to its advantages mentioned above.

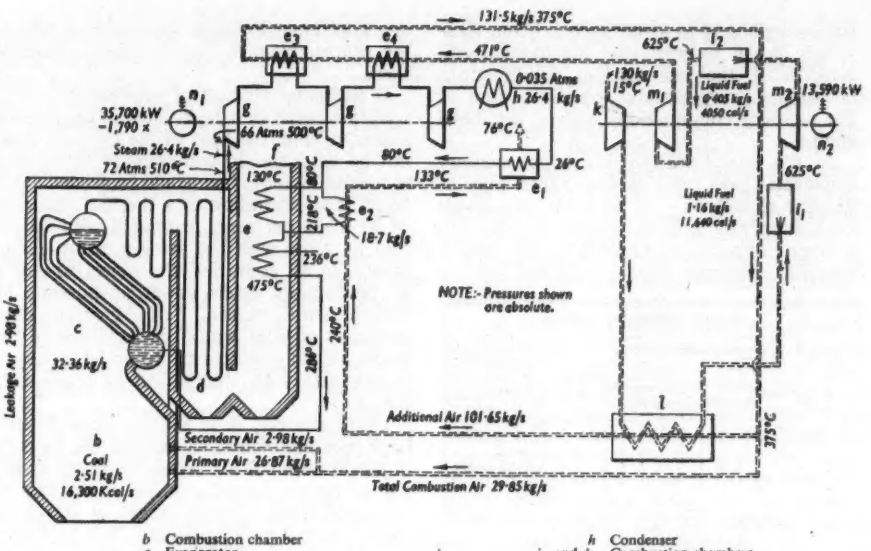


Fig. 5—Standard Steam Plant Incorporating Gas Plant

Combinations with Condensing Plants for Power Stations

Combinations with steam plants of relatively low pressure (below 70 atmospheres), will give considerable increases in overall efficiency, i.e. an improvement of up to 10 per cent and more in fuel consumption. As soon as one provides combinations with modern high power plants, some new conceptions have to be introduced into the outlet of the steam part. For example, the ordinary air preheater is no longer useful, the " combustion air " being available at elevated temperatures from the gas turbine side. Therefore, the boiler gases are to be cooled down by the feed water instead of the fresh air ; the feed water heating by bled steam has, therefore, to be reduced or eliminated.

Although the reduction of the bled-steam circuit means an increase in losses on the steam side, the overall losses of the combined plant remain, nevertheless, below the overall losses of the ordinary steam plant.

The closer the two plants are linked, the higher will be the thermal efficiency at somewhat increasing additional cost. The increase in initial costs is, however, not very important, when one considers that, to increase the thermal efficiency by 13 per cent, an additional outlay of only 13 per cent suffices. Minute investigations have shown that the additional outlay can in all instances be written off in a few years, so that after this short time the fuel saved can be regarded as clear profit. These figures, however, hold good only for the use of the gas turbine in the steam-gas arrangement (gas turbine with oil combustion chamber of its own, or for burning tar or gas). For the steam-air arrangement, the gain is somewhat smaller, the additional cost higher, due to the complication resulting from the incorporation of the air heater in the boiler.

How does such a combination look now, if it is to bring about an improvement in efficiency of 10 per cent ?

Figs. 4 and 5 show diagrammatically such a combination. Fig. 4 illustrates the standard steam plant, Fig. 5 the gas turbine combination co-ordinated thereto. It may be observed that in this very far-applied interlinking of both plants, the exhaust gases of the gas turbine plant not only are passed on to the boiler as combustion air, but they are used also in the resuperheating of the steam and the preheating of the feed water. The thermal efficiency of such combined plants can attain considerable values. For instance, with a 50,000kW plant at 72 atmospheres boiler pressure, and 510 deg. Cent. steam temperature, a coupling efficiency of about 36·1 per cent as compared to 31·6 per cent in a customary steam plant is attained. Thereby about a quarter of the total output has to be furnished by the gas turbine. The steam quantity of the boiler decreases to about half of that of a customary steam plant, the condenser can be reduced to two-thirds and the economiser to about 60 per cent. The air preheater and all bleeds can be dispensed with.

When applying the combinations suggested to the extreme high pressures and steam temperatures used nowadays, total efficiencies of 40 per cent may be attained.

Recapitulating, Fig. 6 gives these efficiences compared to those of customary plants.

In the lower portion the thermal efficiencies have been plotted. We find, for instance, the following data :

Steam plants without and with a resuperheating on the boiler side 31 to 35 per cent., mercury-steam plants 37 to 38 per cent.,

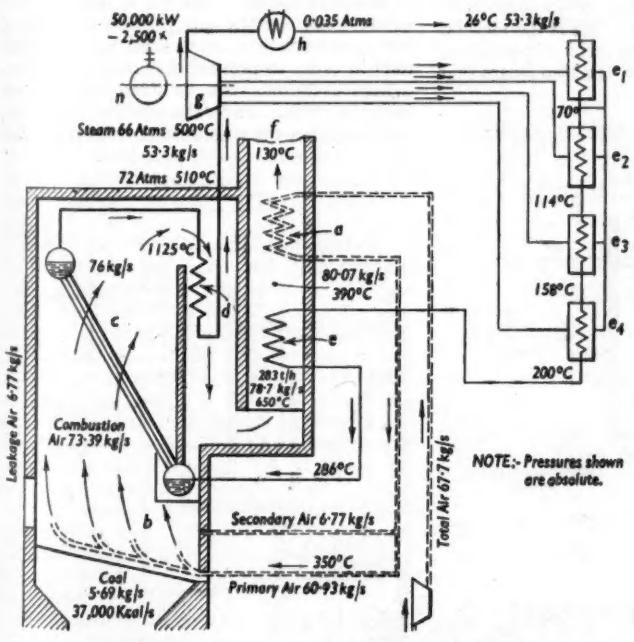


Fig. 4—Standard Steam Plant

diesel engines 38 to 41 per cent. From these values it will be seen that the thermal efficiencies of the gas turbine combinations (steam-gas) very closely approach those of the mercury combinations and of the diesel engines.

In the upper portion, the supplementary efficiencies have been plotted, which may be defined as follows. If we have two plants both supplying a fixed amount of heat but different amounts of power, then the supplementary efficiency ($\eta\Delta$) is defined as the

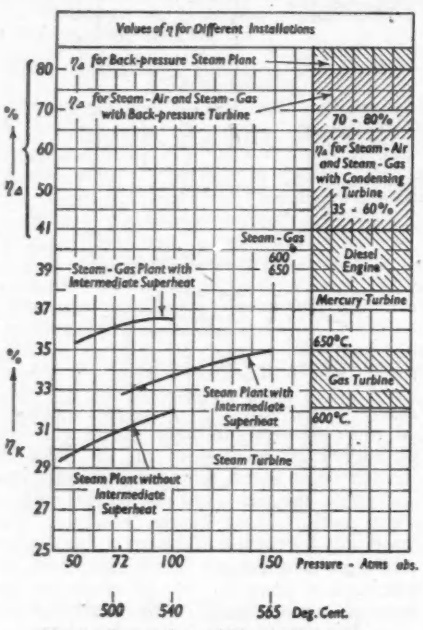


Fig. 6—Comparison of Plant Efficiencies

ratio of the additional output to the additional heat required.

From Fig. 6 it may also be gathered that the extension of existing plants by adding a gas turbine and modifying the steam turbine for intermediate reheating outside the boilers, while maintaining and but slightly altering the low-pressure boilers, results in higher efficiencies than would be obtainable in the most modern of steam plants using new high-pressure boilers and intermediate reheating in the boilers.

Combinations with Back-Pressure Plants for Industrial Purposes

(a) *Steam-Air Plant.*—In many industries heat is required in the form of steam. If power is also to be generated, a back-pressure steam turbine *g* is added to the system shown in Fig. 7. The boiler pressure must be increased. In Fig. 8 the steam pressure postulated at the superheater outlet is 40 atmospheres absolute (555 lb per square inch gauge) at 350 deg. Cent. (662 deg. Fah.). The steam, after expansion in the turbine, is at a pressure of 5 atmospheres absolute and 165 deg. Cent. The higher the pressure to which the steam is raised at the inlet of the turbine, the greater is the output which can be obtained from it, but there are practical upper limits to the pressure and temperature.

Power is produced in the turbine at the expense of additional coal consumed in the boiler over that required in the arrangement shown in Fig. 7.

The increase is, however, small and about 80 to 85 per cent of it appears as additional power, while only 15 to 20 per cent is necessitated by the additional losses resulting from higher boiler pressure and from friction in the turbine bearings. The power produced in the back-pressure turbine does not involve any additional losses in the steam system at the process plant *h*, since nothing is changed there.

If the same amount of mechanical energy were produced in a high-vacuum condensing steam turbine, the heat in the exhaust could not be used and in consequence from three to four times more fuel would be needed at the boiler, corresponding to a thermal efficiency of 20 to 30 per cent, compared with 80 per cent or more with the back-pressure plant. Hence, in all countries, the object to-day is to produce as much power as possible by back-pressure plants. The greatest conservation of fuel would be achieved if the whole output of a country could be produced in this way with elimination of condensing plants.

Unfortunately, it is seldom possible in a back-pressure system to balance the amount of steam required for heating with the quantity of power desired. More power can be produced from a given weight of steam by increasing the boiler pressure, but even with the highest practicable pressure it is not always possible to balance the power and the steam demand for heating purposes.

When power out-balances process steam there is recourse to pass-out condensing turbines, by which the power deficiency is made up with the aid of supplementary steam. A particularly favourable solution of this problem is obtained when the exhaust from the additional steam used for power generation exactly balances the additional steam requirements for preheating the feed water ; this is known as the " preheater turbine." (Fig. 9), Here the sensible heat of the flue gases from the boiler is not used for feed water preheating, but for preheating air.

If the ratio of power to heating steam is required to be still greater, the only method by present practice is to use additional steam in the turbine *g* and expand to vacuum this additional steam that is not required by the heating system ; the heat of condensation of this steam is then lost. This is the method of the pass-out condensing turbine in common use to-day ; here it is only the bled steam that

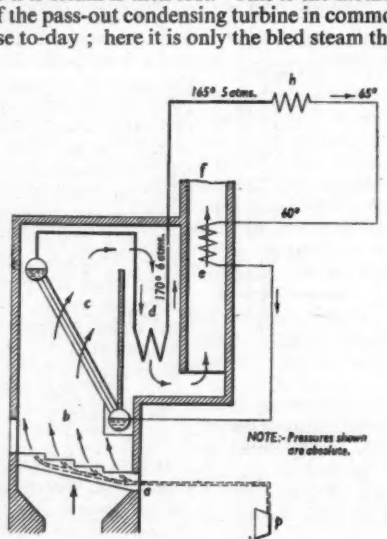


Fig. 7—Plant for Process Steam

works with high efficiencies and the heat of the exhaust steam and condensate is lost.

It is here that the gas turbine comes into the picture.

The insertion of a gas turbine in the combustion air system of the boiler plant successfully achieves for this part of the system what has been long the practice on the steam side, namely, the production of additional power by a machine which involves but little additional expenditure of heat.

The gas turbine operates on air which is raised to the necessary inlet temperature by heat interchange with the hot flue gases. Fig. 10 gives the layout of the plant.

The atmospheric pressure air heater a^x (Fig. 9) is replaced by an air heater operating with air under pressure of a few atmospheres, or it can be heated by partial combustion in a separate combustion chamber.

Air is compressed to 3 to 4 atmospheres absolute (28·5 lb to 43 lb per square inch gauge), and is heated in the air heater *i* to the inlet temperature permissible in the gas turbine to-day of approximately 600 deg. to 650 deg. Cent. (1112 deg. to 1202 deg. Fah.).

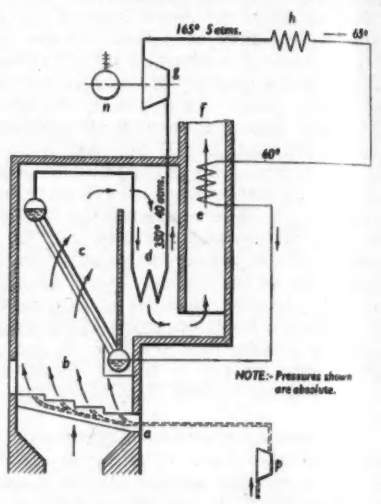


Fig. 8—Process Steam from Back-Pressure Plant

It then expands in the air turbine *m*, which drives the generator n_1, and on leaving the turbine is returned to the boiler at *a* as combustion air. The temperature of the air at the inlet to the boiler is the same as that at the outlet of the gas turbine. Should a lower temperature be desired at the boiler inlet in order to prevent damage to the grate, a heat exchanger can be fixed between the turbine outlet and the boiler inlet to preheat either the compressed air or the boiler

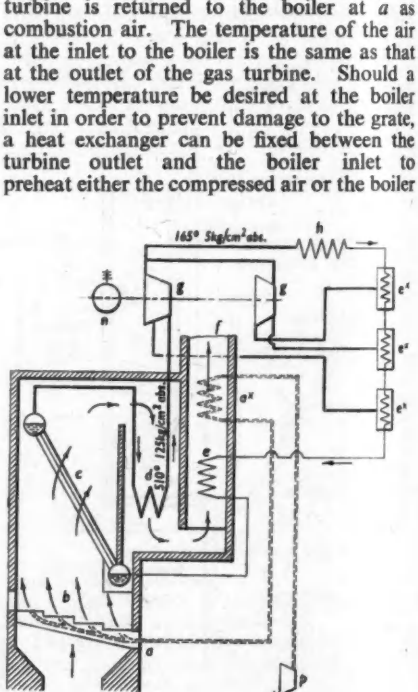


Fig. 9—Preheater Turbine

feed water ; this will not appreciably affect either the output or the efficiency of the plant.

In Fig. 10 there is shown a branch leading from the combustion air duct to apparatus e_1 and h_1, through which passes any additional air used in the gas turbine and not required for combustion in the boiler furnace. This additional air increases the output of the

air turbine ; the heat in this additional air is partly transferred to the steam by preheating the feed water in the supplementary economiser e_1. It cannot all be used for this purpose, however, and the remainder, at a temperature of probably 100 deg. Cent., must be written off as lost unless there is a special outlet for heating by hot air as shown at h_1, e.g. for space heating during the winter or for drying. The use of additional air raises the output of the gas turbine, but mainly at the cost of efficiency. It will be shown, however, that by the use of the maximum possible amount of extra air, and without utilising its heat at exhaust, efficiencies can be obtained which are much above those of pure condensing power plants.

The efficiency of the combined plant is between 66 and 68 per cent without extra air being used in the gas turbine, and between 48 and 50 per cent with maximum additional air, both these figures being calculated on the assumption that the exhaust heat of the

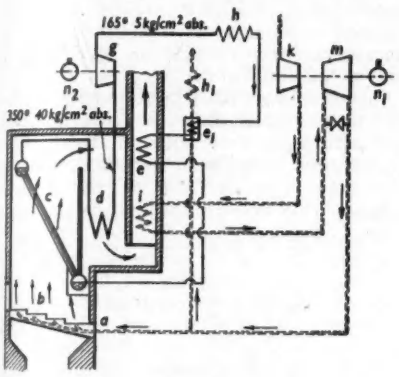


Fig. 10—"Steam-Air" Plant

additional air cannot be used. If the exhaust heat could be used the efficiencies would be greater and would rise above 50 per cent for the maximum additional output.

Corresponding to the higher stresses upon the material on the steam side, the inlet temperature of the air to the gas turbine has been progressively raised in passing from low to high pressure ; the temperatures postulated for the gas turbine, however, are within the range that can be covered by the materials available to-day.

It may be seen that by incorporation of the gas turbine the output of a back-pressure steam plant can be nearly doubled, and that the additional power is secured with efficiencies of the order of 40 to 50 per cent. when the exhaust heat in the extra air is not utilised (i.e. apparatus h_1 in Fig. 10 cannot be applied) and above 60 per cent when this heat is utilised. Compared with a high-pressure plant with preheater turbine the increase in output is about half of that of an ordinary back-pressure plant.

From the standpoint of the rational utilisation of fuel, the incorporation in a power plant of the gas turbine as a power producer is just as essential as is the incorporation of a back-pressure steam unit.

(b) *Steam-Gas Plant* (*Example of an Industrial Application*).—Instead of the system represented in Fig. 10, the working fluid of the gas turbine can be supplied by burning the compressed air from the compressor direct in a combustion chamber as described above.

This system is particularly suitable as an extension of oil-fired steam boilers because the same fuel, i.e. low-grade fuel oil, can be burnt both in the boiler and in the combustion chamber of the gas turbine.

As an example we take the power station of a factory, which has to supply an electrical output of 1900kW and a quantity of heat amounting to 31,800,000 B.Th.U. per hour. The heat will be used in the factory to a minimal temperature of about 194 deg. Fah. Fresh cooling water at an average temperature of 68 deg. Fah. is available.

A classical solution would be, for example, as follows :—

Of the 1900kW, 1900kW would be produced by means of a back-pressure turbine in combination with the generation of the heat ; 1000kW would have to be produced by a separate condensing turbine.

For this the boiler would deliver 39,680 lb per hour of steam at a pressure of 355·6 lb per square inch absolute and 797 deg. Fah. The turbine would work with a back pressure of 64 lb per square inch absolute and supply the steam to the factory at a temperature of 482 deg. Fah.

In the solution with gas turbine, in the "steam-gas" combination, the condensing turbine would be replaced by a gas turbine of equal output.

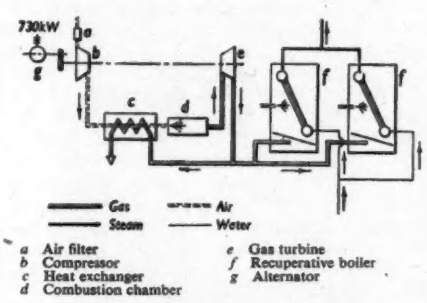
The omission of the condensing turbine would diminish the quantity of steam to be generated by 11,020 lb per hour. This would cause a reduction in the amount of heat required from the fuel, as set out in the following table.

Consumption of Fuel Heat

	B.Th.U./hour
With condensing turbine	63,600,000
With gas turbine	51,451,000
Saving with gas turbine, i.e. about 19 per cent ...	12,149,000

In conformity with this practical example a boiler efficiency of about 80 per cent was assumed.

By the inclusion of a gas turbine in the air cycle of a thermal plant it is therefore possible to produce electrical energy at a considerably higher efficiency than with an additional condensing turbine. If there were no condensing turbine but only a back-



a Air filter
b Compressor
c Heat exchanger
d Combustion chamber
e Gas turbine
f Recuperative boiler
g Alternator

Fig. 11—"Bone II" Power Station

pressure turbine of 900kW, then in this example it would be possible without any further consideration to double the output by the inclusion of a gas turbine and without increasing the boiler capacity.*

Steam-Gas Central Station Plant for Algeria

A very interesting steam-gas plant order has been placed with the Oerlikon Company by the Electricite et Gaz d'Algerie. (Fig. 11.)

Here the gas turbine is intended as an additional power plant to the big main station. It is provided for generating the energy for the auxiliaries and the steam for certain additional services, especially for preheating the heavy fuel.† It must be capable of running parallel with the main grid, as well as procuring its output of 730kW independently from the grid, especially in emergency cases.

According to Fig. 11 the waste gases of gas turbine *e* can be sent either to the recuperator *c* of the plant or to two boilers of about 7·50 tons per hour total steam production. These boilers are fitted with two burners each ; they also are able to run independently (*marche autonome*).

If the burners of the boilers are not in service, the boilers run as so-called "waste-heat" boilers, getting their total heat merely by heat exchange with the waste heat gases of the gas turbine. In this *marche en recuperation* a little more than the half of the maximum boiler output may be produced.

If more steam is required than the waste-heat gases of the turbine may furnish, the burners may be ignited, so that the boilers receive their heat partly from the gases of the gas turbine, partly from the fuel burnt in these burners. In this *marche mixte* the principle of the "steam-gas plant," as described above, is realised. In this case the output of the gas turbine is obtained at efficiencies between 40 and 50 per cent, if one compares the combined plant with a mere heat plant which would have the efficiency of the boiler. The fuel used for the gas turbine plant is the same as for the boilers (Bunker C).

In this way the "Bone" gas turbine plant permits the greatest flexibility of operation.

* For details see *Bulletin Oerlikon*, No. 276, pages 1880–1884, article by de Reynier and Kowalczewski.

† Congres des Entrepreneurs des travaux publiques Alger, April, 1951, by M. Seurat, Chief Engineer at the Electricite et Gaz d'Algerie.

Work at Wolf Rock Lighthouse

We have received from Holman Brothers, Ltd., Camborne, some particulars of a rock drilling job carried out under somewhat unusual conditions at Wolf Rock Lighthouse. The work was done in connection with the erection of a new 2½-ton crane post for which a hole 7½ft deep by 2ft diameter had to be drilled in the lighthouse jetty.

No blasting was permissible owing to the close proximity of the lighthouse, and it was decided to drill a series of holes to each round and break them one into the other with a road ripper.

Holman Brothers, Ltd., were consulted by Trinity House and it was decided to use the following equipment :—A "T.13 D." compressor, a "Silver Bullet Handril" of 4½in shank with a 1in hexagon steel, using "Holbits," and an "SS 33" road ripper with plugs and feathers. Two special tools also made for this particular job were a scoop for clearing the rubble from the bottom of the hole as the depth increased and a tool for guiding the drill steel around the bottom of the hole after a depth of 3ft had been reached.

Because of the extreme difficulty of carrying out this operation on the Wolf Rock and to eliminate the possibility of mistakes, the operators spent four weeks at the Holman test mine, where they were given special training in the use of rock drills. A hole 6ft 6in deep was drilled in the solid granite of the test mine, and every forseeable point in the drilling operation was carefully rehearsed.

The compressed air supply for working the drills was supplied by pipe-line from a "T.13 D." compressor housed in the hold of the Mousehole fishing boat "Renovelle," which was anchored some distance off the rock. On May 5th the compressor, drilling equipment and stores were loaded on to the "Renovelle," but adverse weather conditions made it impossible for a landing on the rock until May 23rd. Conditions became favourable for drilling to commence on May 26th.

The seas running off the Wolff Rock do not allow the lighthouse to be approached every day, even then only a few hours' work can be done at a time at low tide. The complete drilling operation took sixty actual hours spread over a month, and the entire operation was successful and the new mast was placed in position on July 14th

Density Measurement of Concrete Slabs Using Gamma Radiation

By E. E. SMITH,* B.Sc., A.Inst.P. and A. C. WHIFFIN,† Ph.D., M.Sc. (Eng.), A.M.I.Mech.E.

In studying the various factors affecting the performance of surface vibrators used to compact freshly placed concrete road slabs it was necessary to devise a rapid method of determining the density of the concrete at various depths in the slabs, which were 4ft wide by 18in deep. Preliminary investigations to assess the feasibility of the proposal that the density might be determined from the absorption by the concrete of X or gamma radiation are described. An outline is given of the physical basis of the method, and indications are given of the range and limitations of the technique. Details are given of the apparatus finally developed. The method enables density of concrete to be determined to an accuracy of 0·02 gramme per cubic centimetre (standard deviation), which is more than adequate for investigating variations in density in road slabs.

THIS article describes the determination of the density at various depths in concrete slabs by measuring the absorption of gamma radiation passing through a known thickness of the material. Although the technique described is used to obtain the density/depth gradient in concrete slabs compacted by an experimental surface vibrator, the method can also be used to make similar measurements in road slabs and to determine the bulk density of soil.

The present method replaces an earlier technique of drilling cores and slicing them up with a diamond saw.[1] This technique was very laborious and time-consuming owing to the fact that the concrete was not sufficiently strong to be drilled until it had cured for twenty-eight days. The present technique can be employed as soon as the concrete has set sufficiently to permit removal of the formwork, and it enables a much more detailed study to be made of the variation of the density/depth gradient along the slab than can be obtained from two or three cores.

The main purpose of the research in which this technique has been employed is to determine the best values of frequency and amplitude, and the other variables associated with surface vibrators used to give compaction of freshly placed concrete of the type employed in road construction. An experimental vibrator has been developed for the investigation,[2] and measurements are made with piezoelectric gauges of the vibration generated at various depths in the concrete.[3] The basis of the research is the determination of the density/depth gradient obtained and its variation with the controlled variables.

The original suggestion to employ X or gamma radiation to determine the density of the concrete slabs was made by the Road Research Laboratory, and the Physics Division of the National Physical Laboratory was asked to explore the possibilities and to indicate the lines on which a practical method could be based. The first part of this article outlines the physical basis of the technique and describes the preliminary work, while the later part describes its application to the test slabs laid by the vibrator.

Physical Basis of the Method and Preliminary Tests

The absorption of X and gamma radiation is due to interactions which take place between the rays and the atoms which comprise the absorbing medium. There are two main kinds of interaction: one in which the ray gives up all its energy and is thus completely absorbed, and another in which only part of the energy is lost, the remainder being scattered at an angle to the incident ray. The total amount of energy reaching a point on the emergent side of an absorber is therefore the sum of the residue of the direct beam plus a possibly preponderant amount of scattered radiation, the precise quantity of which depends, amongst other things, on the dimensions of the absorbing material. Whilst the fundamental processes are well understood, it is difficult to calculate the absorption or transmission of radiation under these so-called "broad-beam" conditions of irradiation. On the other hand, if the scattered radiation is prevented from affecting the measuring system, it appears as if it has also been absorbed and "narrow-beam" conditions are achieved. In such circumstances it is possible, given the thickness, density and chemical composition of a medium, to calculate the transmission for any particular energy of X or gamma radiation. Alternatively, the density of a medium can be calculated if the transmission of a particular radiation is measured under narrow beam conditions and the thickness and composition are known. In the case of concrete, however, both the composition and the density are liable to be unknown and variable. Fortunately, over a wide band of quantum energies, ranging from about 0·2 to 3 million electron volts (0·2 to 3MeV), the absorption of X or gamma-rays is largely independent of chemical composition, particularly in the case of the light elements normally to be found in concrete. It follows, therefore, that in this range of energies the transmission of any particular radiation is dependent almost solely on the mass of material penetrated. Thus, by measuring the narrow beam transmission and knowing the thickness penetrated the density can be determined with some precision.

In the experiments associated with the surface vibrator the concrete slabs were 10ft long by 4ft wide and 18in deep. The measurement of the density at any chosen depth thus involved the penetration of a maximum of 4ft of concrete. A consideration of the magnitudes of the absorption coefficients of X and gamma-rays in concrete indicates that, even for thicknesses of the order of 1ft or 2ft, a highly penetrating radiation is required. It is found that even with the most penetrating radiation conveniently available (e.g. the gamma-rays from radioactive materials), it is impracticable to make measurements through the entire 4ft width of the slabs, 3ft being about the upper limit with sources of reasonable magnitude, and 2ft a convenient working thickness. X-ray equipment is not considered suitable for this work as it would have to operate in the million volt region for measurements through 4ft of concrete to be possible. Such equipment is costly and bulky and not suited to operations in the field.

It was accordingly decided to make preliminary experiments using radium as the source of radiation. At the time (1945) this was the only suitable material readily available, although subsequent developments in nuclear physics have made available other radioactive materials, such as radio-cobalt (Co^{60}). The gamma-rays from radium have a complex line spectrum of energy ranging from about 0·25 to 2·2MeV, which is within the range specified above as being necessary for determining the density of concrete. The activity of radium falls to half in about 1600 years, so that, for practical purposes, radium may be regarded as a constant source of high energy radiation. Radio-cobalt, on the other hand, emits only two energies of gamma radiation, viz., 1·17 and 1·33MeV and has a half life of 5·3 years. The short half life necessitates periodical allowance being made for the fall in activity, but the material is cheap in comparison with radium and is available in a much more robust form. Consequently, although the preliminary experiments were made with radium, the subsequent application of the technique to measurements in the field has been based on the use of radio-cobalt.

Measurements have been published[4, 5] of the narrow-beam absorption in concrete of the gamma-rays from both radium and radio-cobalt, and logarithmic transmission curves for both types of radiation are given in Fig. 1. The curve for radio-cobalt is linear,

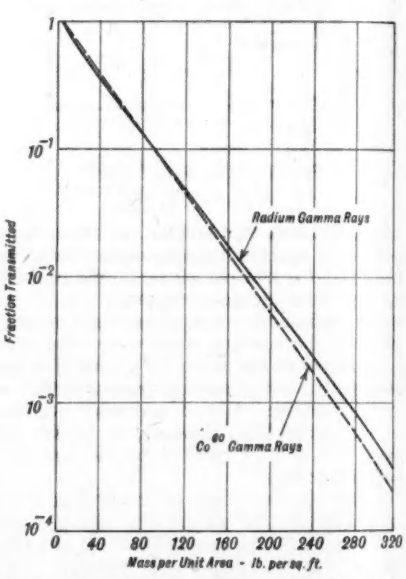


Fig. 1—Transmission of Radium and Radio-cobalt Gamma Rays through Concrete

indicating that the radiation behaves as if it were monochromatic. In the case of radium, however, the initial part of the curve is somewhat steeper than that for radio-cobalt, but ultimately, as the lower energies are removed by absorption, the radium radiation becomes the more penetrating of the two. From these curves can be obtained the fractional transmission corresponding to a particular absorbing layer. For example, a 2ft thickness of concrete of density 2·2 grammes per cubic centimetre (137·5 lb per cubic foot) is equal to an absorbing layer of 275 lb per square foot. This represents fractional transmissions of $6{\cdot}4 \times 10^{-4}$ and $9{\cdot}5 \times 10^{-4}$ for radio-cobalt and radium gamma-rays respectively. Owing to the logarithmic nature of the absorption process a small change of density corresponds to a much larger change in transmission, and thus the response of the measuring instrument is quite sensitive to changes in density.

The arrangement for the preliminary experiments is shown in Fig. 2. Three 4ft

* National Physical Laboratory
† Road Research Laboratory

square concrete slabs were cast, two being provided with a central hole 3in in diameter, into which the source of radiation could be lowered. The slabs were arranged in a pile so that measurements of the transmission throughout the depth of both the top and middle slabs could be investigated. A Geiger-Muller counter was used to measure the intensity of the emergent radiation. The response of this type of instrument is normally recorded as a number of counts and thus lends itself readily to a statistical evaluation of accuracy. The apparatus available at the time of these preliminary experiments was incapable of handling more than 500 counts

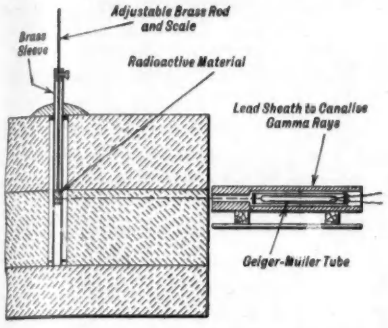


Fig. 2—Experimental Arrangement for Density Measurement

per minute and, even at this rate, losses occurred for which allowance had to be made. This limited the size of source that could be used to about 50 milligrammes of radium element. With improved counting equipment, such as is available to-day, counting rates many times the above value can be recorded without appreciable loss and the size of source is limited only by the amount of radioactive material which it is convenient to handle from the protection point of view. In this connection it is considered that 200 milligrammes of radium, or 130 millicuries of radio-cobalt (which is roughly equivalent as regards gamma-ray emission) is probably the most suitable size of source for the present work.

In order to achieve narrow beam conditions, i.e. to record only the radiation

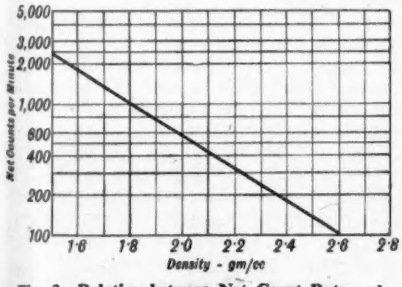


Fig. 3—Relation between Net Count Rate and Density

coming directly from the source, the Geiger-Muller counter was housed in a heavy lead sheath. This sheath was provided with an aperture 1in in diameter and 6in long, through which the direct radiation could pass. Equipment as sensitive as the Geiger-Muller counter is affected by cosmic rays and the radiation from extraneous radioactive material in the vicinity, so there is always a "background count" for which allowance has to be made. The "net count" is obtained by deducting the background count from the measured value. The lead sheath reduced the background count by about 40 per cent (to about fifty counts per minute with this particular counter) and thus served a double purpose.

To make a measurement, the radium was lowered to the desired depth and the Geiger-Muller counter, in its sheath, was adjusted to the same level so that the aperture in the sheath was directly in line with the source of radiation. Care was taken to keep the sheath perpendicular to the face of the slab. When sufficient counts had been obtained the position of the radium was altered and the process repeated. In this way the entire depth of the top two slabs was investigated through each of the faces. The two slabs were then interchanged and further measurements were made. The results indicated that the lead collimating sheath was so effective that it was possible to obtain reliable values to within an inch of the top surface of the upper slab. This is an important consideration where field measurements are concerned, as it is evident that measurements can be made on the slab as cast, the provision of additional material on the top to form a "guard plate" being unnecessary.

The sensitivity of the counting system was determined by using a source consisting of approximately 50 microgrammes of radium element, which, in the absence of concrete but with the other conditions maintained constant, gave about the same count rate as was obtained during the transmission experiments. It was then possible to calculate the fractional transmissions and to read off the corresponding masses of material from the appropriate curve of Fig. 1. A knowledge of the path length (in this case 1ft 10½in) then enabled the densities to be calculated.

It is possible, for any particular experimental arrangement, to construct a curve such as that shown in Fig. 3, from which the density can be read off directly for each net count rate. This curve is approximately linear when plotted semi-logarithmically and its slope is dependent on the path length and the mass absorption coefficient of the radiation employed. The curve is for 50mg of radium and an absorbing path of 1ft 10½in. The corresponding curve for radio-cobalt would be a little steeper as the radiation is more readily absorbed in the region of thicknesses involved. The actual value of the count rate for any particular density depends on the activity of the source and the sensitivity of the Geiger-Muller counter in use.

The densities having been determined in the manner described above, several cores were cut from the slabs and their densities were determined as outlined in the introduction. Satisfactory agreement was found both as regards absolute magnitude and the extent of the variations, thus indicating the soundness of the new technique. The question does arise, however, in applying the technique to field measurements, whether it is better to base the results on published absorption data and a knowledge of the absolute sensitivity of the measuring equipment, or whether it is preferable to calibrate the response of the counting system in terms of densities measured by normal methods. This latter procedure, which is essentially the determination of the transmission/density relationship for the particular apparatus and arrangements employed, should yield more accurate absolute data and has been adopted for the field measurements. Details are given in the next section.

Apparatus for Determining the Density/Depth Gradient in Concrete Slabs Compacted by an Experimental Surface Vibrator

Vertical holes, 2in in diameter, were drilled at 1ft intervals along the centre line of the slab. A radioactive source was lowered to measured depths down each hole in turn, and the radiation emerging at the corresponding depth was measured in succession on both side faces of the slab.

The radioactive source was 130 millicuries of radio-cobalt machined as an approximate cylinder, 14mm long by 14mm diameter, enclosed in a thin-walled, cylindrical, brass housing attached to the lower end of a stainless steel rod carried on the transverse beam shown in Fig. 4. For transport purposes the source, enclosed within a thick-walled lead castle, was detached from the apparatus. When in position the lower end of the castle was removed and the source was lowered out of the castle into the hole in the test slab. The transverse beam supporting the source was lowered by operation of the handwheel

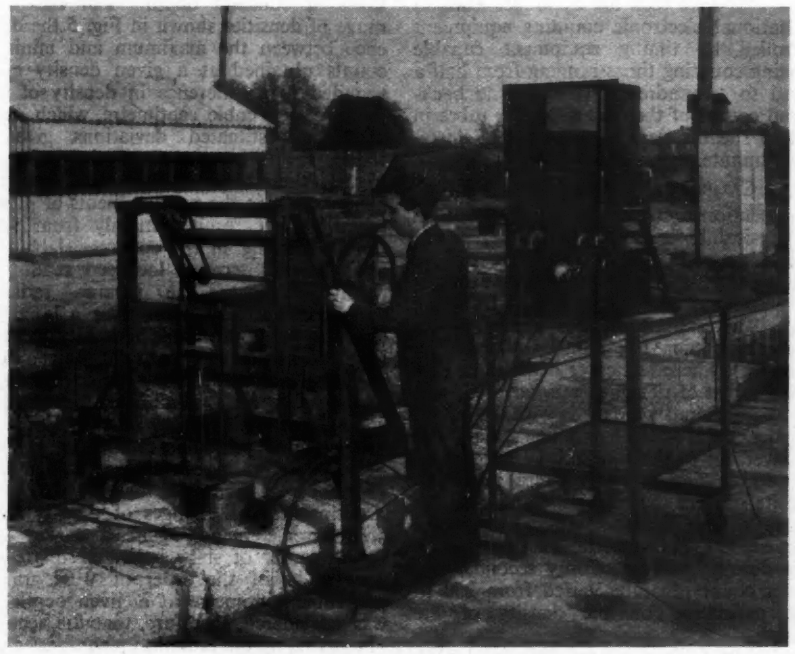


Fig. 4—Apparatus for Field Tests

shown in the photograph, and the depth of the source below the surface of the slab was fixed by pegs supporting the beam and placed in holes in the side members arranged at vertical intervals of 1in.

The transverse beam also carried the apparatus for measuring the intensity of radiation emerging from the side walls of the slab. At each end of the beam was a frame carrying a lead collimating tube, 17in long with walls 1in thick, the axis of each tube being aligned horizontally on the centre of the radioactive source. The internal diameter of each tube was 1in for a length of 7in near the concrete, and was then enlarged slightly to hold a Geiger-Muller tube in a plastic housing. The faces of the lead tubes were 4ft 1in apart and the absorbing path in the concrete was 23in long in the two opposite directions.

Each Geiger-Muller tube was argon-alcohol-filled and fed with a positive anode potential of 1140V from a stabilised power supply. To avoid troubles arising from the long time constants of long connecting leads

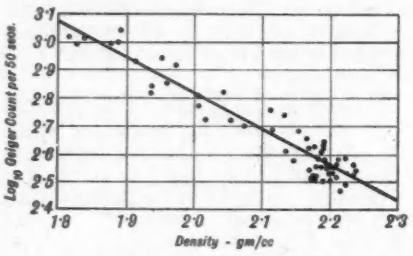


Fig. 5—Calibration Test Results

pre-amplifiers were connected with each tube by short leads and were attached to the frame supporting the collimating tubes. The amplified signals were then fed by longer leads to conventional electronic counting equipment controlled by timing equipment capable of giving counting times ranging from half a second to a hundred minutes. The background counts of the Geiger-Muller tubes in the lead sheaths were of the order of thirty-six per minute.

Calibration of Equipment

As mentioned in the section dealing with the physical basis of the technique, it was decided to calibrate the response of the counting system in terms of densities measured by sectioning cores cut from the slabs. This calibration was made on five of the slabs (each 10ft long by 4ft wide by 18in thick), where test cores had shown that a wide range of densities was covered, and gamma-ray counts were made with the source in vertical holes on the centre line and as near as convenient to the core holes. Frequently two sets of measurements were made on opposite sides of the core hole, and then the average of the four sets of readings was obtained. In these expcriments counts were made during intervals of fifty seconds, and the net count per tube varied from 250 to 1500, depending on the density of the concrete.

The counts were related to the density values at the corresponding depths in the cores, such densities being computed from the weight and volume of each slice cut from the cores and oven dried. The concrete employed in the calibration experiments and in the research on the experimental vibrator consisted of a 1 : 2½ : 5/0·60 mix containing normal Portland cement and river gravel, the only variable being the degree of compaction. In road slabs of such a material exposed to the weather the moisture content usually lies between 3 per cent and 7 per cent by weight and is frequently approximately 5 per cent to 6 per cent. All measurements of the transmission of gamma radiation were made on slabs exposed in the open, while the density measurements were made on oven-dried specimens. When the calibration relating gamma counts to density was employed in the research on the vibrator, therefore, the densities thus deduced were, in fact, "dry densities," it being assumed that the slabs used in calibration and in the main series of tests had similar moisture contents.

The results of the calibration tests are shown in Fig. 5, which gives the best straight line through the experimental points. Since disintegration of radioactive material is a random phenomenon, the standard deviation of the net number of pulses N received by a Geiger-Muller tube in a given time is $100/\sqrt{N}$ per cent. It can be shown that the scatter shown in Fig. 5 was not due to using the relatively short, but very convenient, counting time of fifty seconds, for the corresponding deviation of density ranged from 0·5 per cent to 0·9 per cent (see Table I).

TABLE I—*Deviation of Estimated Values of Density Due to Variation of Geiger-Muller Counts*

Net counts recorded in 50 sec	$\sqrt{N}$	Deviation of N	Density of concrete deduced from N	Deviation of density values	
N		Per cent	gm/cc	gm/cc	Per cent
250	16	6·3	2·333	0·022	0·9
500	22	4·5	2·098	0·015	0·7
750	27	3·7	1·960	0·012	0·6
1000	32	3·2	1·862	0·011	0·6
1250	35	2·8	1·787	0·010	0·6
1500	39	2·6	1·725	0·009	0·5

The line shown in Fig. 5 was used to estimate the values of density given in Table I and their deviation with variation of N. In tests made to estimate the experimental errors several readings were taken with the radioactive source and the Geiger-Muller tubes at constant depth. For the whole range of densities shown in Fig. 5 the difference between the maximum and minimum counts obtained at a given density corresponded to a difference in density of 0·02 gramme per cubic centimetre, which agrees with the estimated deviations given in Table I. The scatter of the points in Fig. 5, therefore, was not due to experimental error in the measurements of gamma radiation, but resulted mainly from variations occurring in the concrete slabs. The core samples gave a localised reading of density, whereas the gamma radiation measurements were made over a long path length in which variations of density occurred. It is known that the density at a given depth varied with position along the slab, a survey of about twenty slabs indicating the maximum variation in each slab to be of the order of 0·05 gramme per cubic centimetre. Moreover, the vibrating beam was rather more restrained at one end than at the other, resulting in small changes of density across a transverse plane—again, a survey of a large number of slabs indicated this difference to be of the order of 0·04 gramme per cubic centimetre at a given depth. It was considered, therefore, that the accuracy obtainable by the radiation technique, giving a standard deviation of 0·02 gramme per cubic centimetre, was adequate for the experiments for which it was devised and is also sufficient for experimental work on roads.

As has been mentioned already, the activity of radio-cobalt falls to half in 5·3 years, so that adjustments have to be made to the calibration curve when measurements are made some time after calibration.

Use of Apparatus in Testing Concrete Slabs

When gamma-ray counts are made at vertical intervals of 1in throughout the 18in depth of a slab, and readings are taken on both sides of the slab at each level, about half an hour is spent in positioning the equipment over the borehole and making the measurements. A complete survey of a slab 10ft long, having borings at foot intervals along the centre line, takes about a day. The average values of density are plotted against depth and used to judge the performance of the experimental vibrator. The object of the experiments with the surface vibrator is to determine the conditions leading to the best possible compaction of road slabs, good compaction being indicated by achieving high densities at considerable depth. Fig. 6 shows

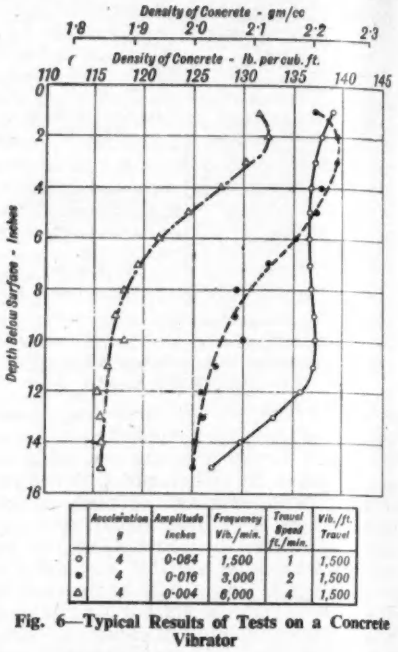


Fig. 6—Typical Results of Tests on a Concrete Vibrator

a sample of the results obtained, average density being plotted against depth for three slabs laid by the vibrator operating at a constant vertical acceleration of 4 g., but with the frequency of vibration and the speed of forward travel varied to give a fixed number of vibrations per foot of travel. Good compaction occurred at 1500 vibrations per minute, using an amplitude of 0·064in, whereas an amplitude of 0·004in at 6000 vibrations per minute gave relatively poor compaction. A detailed account of the results of the experiments on the surface vibrator is being given elsewhere.

It has been explained already that it is not feasible to employ radioactive sources of greater activity to give reliable results with thicknesses of concrete exceeding about 3ft. A very sharp limitation is imposed on the thickness of concrete which can be examined by this technique, the limitation arising from the exponential nature of the absorption process and the inverse square law. It will never be possible, therefore, to test across the whole width of a road slab, which is usually about 11ft. The technique could be used to test the slab near the side verge by lowering the source into a hole about 3ft from this edge and measuring the radiation emerging from the side face. It would be necessary to calibrate the response of the apparatus in terms of the strength of source, path length, and experimental arrangements employed; but, once this was done, the results would not depend on the mix proportions of the concrete nor on the aggregate used. If the equipment was calibrated on concretes of normal mix proportions made with flint aggregate and was then used to test concrete made with aggregate having a density very

different from that of flint, or to study concrete of unusual mix proportions, the results would give the true density, but obviously the degree of compaction could only be inferred by making auxiliary experiments to determine the maximum density obtainable.

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REFERENCES

1 Ministry of Transport, Roads Department Technical Advisory Committee on Experimental Work. "Concrete in road construction." London, 1933: H.M. Stationery Office. Pp. 71–82.
2 Kirkham, R. H. H.: "The Vibration of Concrete Slabs," *Mag. Concr. Res.*, 1949, (3), 141–3.
3 Whiffin, A. C., S. A. H. Morris and R. T. Smith: "The Measurement of Vibration in Freshly Placed Concrete," *Mag. Concr. Res.*, 1950, (4), 39–46.
4 Kaye, G. W. C., G. E. Bell and W. Binks: "The Protection of Radium Workers from Gamma Radiation," *Brit. J. Radiol.*, 1936, 9, 161.
5 Kennedy, R. J., H. O. Wyckoff and W. A. Snyder: "Concrete as a Protective Barrier for Gamma-Rays from Co^{60}," *Bur. Stand. J. Res., Wash.*, 1950, (44), 157.

Electrical Drive for a 42½in Cogging Mill

The rolling mill at the Redbourn Works of Richard Thomas and Baldwins, Ltd., Scunthorpe, consists of a battery of gas-fired soaking pits, a 42½in cogging mill, a bloom shear and a 36in stand finishing mill. An average weekly output of about 6000 to 6500 tons finished weight of billets and slabs is obtained from this mill. A description of the electrical drive of the cogging mill, with particular reference to the G.E.C. cascade exciter control system is given herewith.

INGOTS for the rolling mill at the Richard Thomas and Baldwins, Ltd., Redbourn Works, are heated in four "long" regenerative soaking pits fired with a mixture of blast-furnace and coke-oven gas, and in a one-way fired pit burning coke oven gas. Each pit is capable of holding twenty of the standard 3-ton ingots or sixteen of the 5-ton slab ingots. To complete the soaking pit installation there are six Stein and Atkinson mixed-gas-fired recuperative cubicles, each capable of holding six 3-ton ingots or three 5-ton ingots.

The cogging stand has rolls with 42½in centres and 9ft barrel and, prior to the electrification of the mill, these rolls were driven by a Galloway three-cylinder reversing steam engine. The products of the cogging mill are slabs varying from 9in to 34in in width and 1¾in to 6in in thickness, and blooms of 5in square and upwards.

They are cogged from the standard 3-ton ingots of 20in square section or from the 5-ton slab ingots of 37½in by 19in cross section. The 3-ton ingot is reduced to a 5½in square boom for the finishing mill in nineteen passes, after which it passes to the down-cutting Davy shears, and is then passed to the single stand finishing mill, which has rolls of 36in centres and 7ft barrel. This mill produces billets 2in to 5in square and slabs from 4in to 8in wide by 2in thick. Large slabs from the cogging mill by-pass the mill and are placed directly on to cooling beds.

From the finishing mill the billets and slabs pass through an electrically driven shear, where they are cut to the required length before being pushed on to one of four cooling beds.

ELECTRICAL EQUIPMENT

The cogging mill (Fig. 1) is driven by a 5000 h.p. (r.m.s.) d.c. motor housed in a motor room adjacent to the mill. The motor room also contains the Ward-Leonard Ilgner set (which supplies power to the mill motor), the main switchboard and control desk, and the liquid starter and slip regulator for the driving motor of the Ward-Leonard set. To prevent the ingress of dust from the mill, an air pressure of ¼in water gauge is maintained inside the motor room by two electrically driven fans mounted in the roof. These fans, which also supply cooling air to the machines in the motor room, are driven by 90 h.p. squirrel-cage induction motors running at 730 r.p.m. The basement of the motor room (Fig. 5) houses the main and cascade exciter sets for the mill drive, an auxiliary motor generator set and a cascade exciter set for the screwdowns and breast rolls and three reversible high-speed circuit breakers which protect the main generators.

Standard steelworks motors are used for the screwdown and breast roll auxiliary drives and all drives are controlled from a desk (Fig. 2) in a pulpit overlooking the mill.

The main mill motor (Fig. 3) is a compensated, shunt-wound, reversing machine operating over a speed range of 0–50 r.p.m. by Ward-Leonard control and from 50–100 r.p.m. by shunt control, and is rated at 5000 h.p. (r.m.s.) at ±700V, with a working peak of 12,500 h.p. at 50 r.p.m. and a maximum cut-out peak of 15,000 h.p. at the same speed. It has two pedestal journal bearings which are flow lubricated from motor-driven oil pumps and the oil circuit incorporates a flow indicator with alarm contacts.

Direct current for the main mill motor is provided by an Ilgner motor generator set (Fig. 4), consisting of three d.c. generators direct-coupled to a 3000 h.p. slip-ring induction motor. The flywheel is 9ft 6in in diameter and 32¾ tons in weight and is designed to give a total

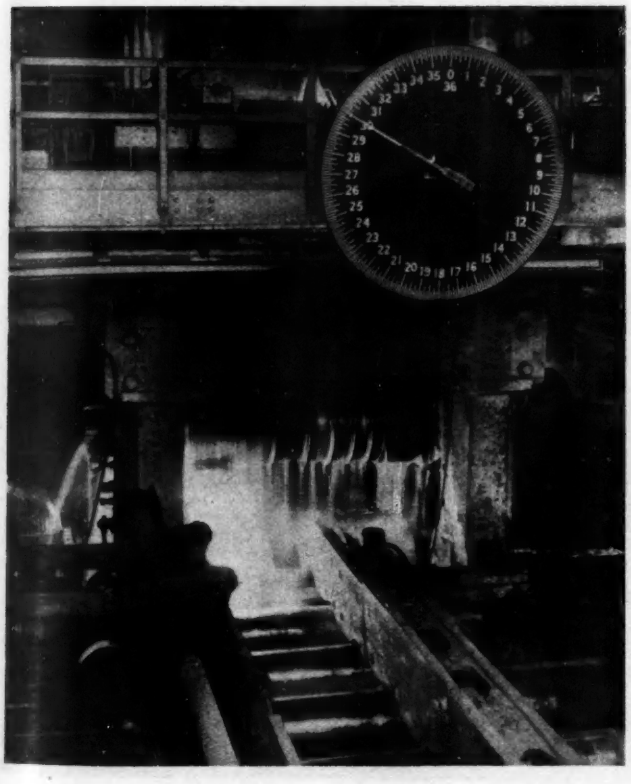


Fig. 1—42½in Cogging Mill at Redbourn Works

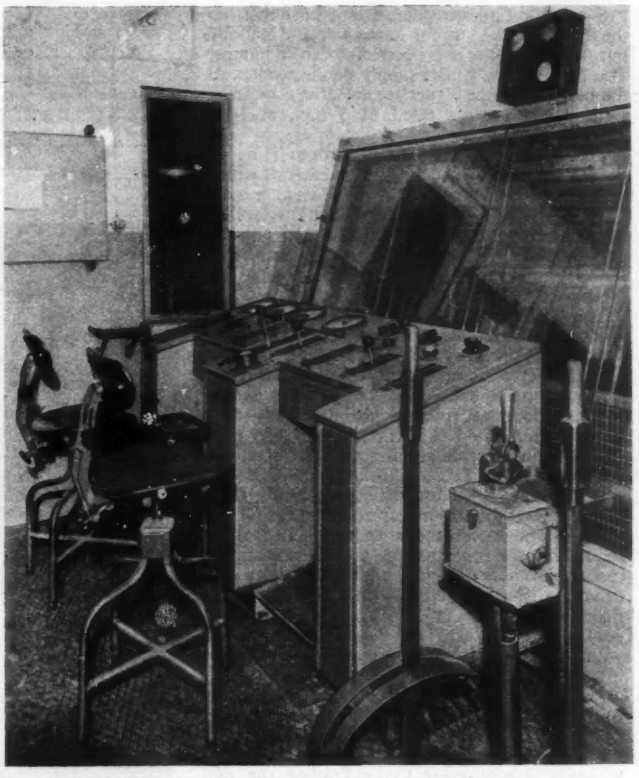


Fig. 2—Control Desk of Cogging Mill

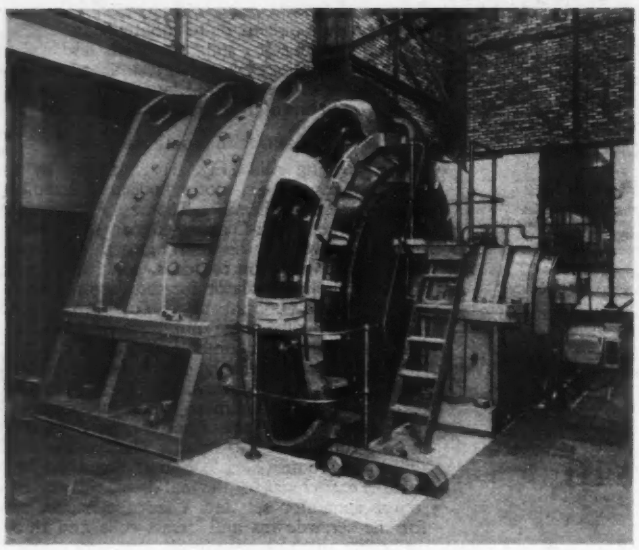


Fig. 3—5000 h.p. Cogging Mill Motor

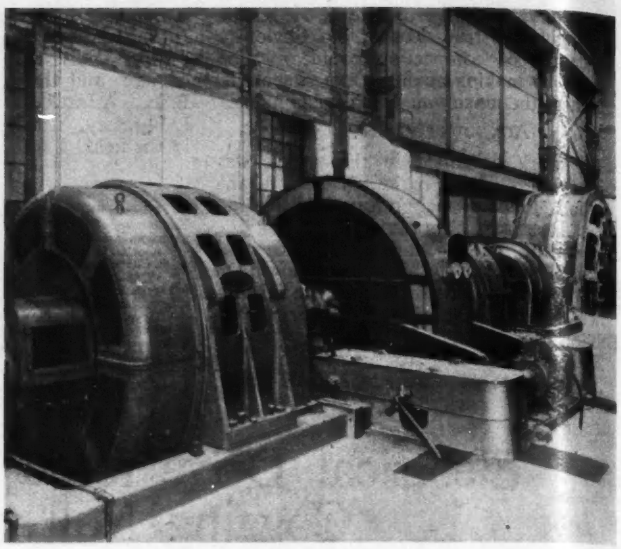


Fig. 4—3000 h.p. Ward Leonard Ilgner Set

stored energy of 150,000 h.p. seconds. The induction motor, which operates from an 11kV supply and drives the set at approximately 735 r.p.m., has a synchronous speed of 750 r.p.m., and a maximum operating peak rating of 6000 h.p. for fifteen seconds. Each of the three generators has an output of 1333kW (r.m.s.) at 700V and a maximum operating peak output of 3332kW for fifteen seconds. The three machines are normally connected in parallel, but change-over links are provided to enable the mill to be run at reduced output with any selected pair of generators. All the machines are fitted with forced-lubricated bearings, which, with the exception of the two outer bearings, are water cooled. The flywheel runs in swivelled pedestal bearings, 13in in diameter and 27in long, which are also forced lubricated ; all bearings are fitted with pressure gauges and dial thermometers with alarm contacts. Pressure lubrication for normal operation is effected by two geared oil pumps which are belt driven from the flywheel shaft but, for starting up and standby purposes, there are two electrically driven pumps. The four pumps which supply cooling water to the bearings of the Ilgner set are driven by 460V squirrel-cage motors rated at 5 h.p., at 1440 r.p.m.

The basement of the motor room (Fig. 5) houses four motor generator sets, each of which is driven by a protected squirrel-cage motor. Two of the sets provide the excitation for the main drive and the others are associated with the d.c. supplies for the auxiliary drives. The functions and ratings of the various machines are given in the accompanying table.

The screwdown motors are standard steelworks motors, and are rated at 100/200 h.p., 230/460V, 475/950 r.p.m. They are mounted on a platform above the cogging mill and are forced ventilated from the main ventilating fans in the motor room. The breast rolls are also driven by steelworks motors rated at 25 h.p., 230V, 1300 r.p.m.

The main switchboard for the control of the d.c. and auxiliary a.c. supplies is an open flat-back equipment designed for remote operation from control desks in the motor room and the mill pulpit. The motor room desk, which controls the mill motor generator set, the screwdown and cascade exciter sets and all the auxiliary a.c. drives, is shown together with a portion of the main switchboard in Fig. 7. Each starter is controlled by " start " and " stop " push buttons with red and green indicator lamps, and sequence interlocking is provided. The desk is fitted with an annunciator panel which indicates any failure in the auxiliary a.c. circuits and audible warning of the fault is also given by a Klaxon horn mounted on the main switchboard. To enable a newly started ingot to be finished the mill continues to run for a period of three minutes from the occurrence of such a fault, and at the end of this time the whole mill is automatically shut down.

The main drive, screwdowns and breast rolls are controlled from the mill pulpit desk through reversing cam controllers. Similar controls are provided for the ingoing and outgoing racks and the desk is fitted with a speed indicator for the main drive and a position indicator for the screwdowns. A " stop " push button placed in the centre of the desk in a position convenient to both operators enables the complete mill to be shut down in an emergency.

The liquid starter and slip regulator for the 3000 h.p. induction motor of the main motor generator set has moving and fixed electrodes in the form of phosphor bronze grids operating in rubber-lined steel pots entirely immersed in the solution. In the full-on position the electrodes are prevented from making contact with each other, the amount of resistance left in circuit

Functions and Ratings of Motor Generator and Exciter Sets

Description	Generators				Driving motor
	For main drive excitation*				
Exciter sets	Generator field exciter, *GFE*, 9·6kW	Mill motor exciter, *MFE*, 22/200kW	Constant voltage exciter, *CVE*, 40kW	—	140 h.p. 2200V 970 r.p.m.
	Main exciter, *ME1*, 1kW	Pilot exciter, *PE1*, 1kW	Main exciter, *ME2*, 1kW	Pilot exciter, *PE2*, 1kW	40 h.p. 460V 1450 r.p.m.
	For auxiliary drives				
M.G. set	Screwdown generator 1, 85/170kW	Screwdown generator 2, 85/170kW	Breast roll generator, 0/44kW	—	575 h.p. 2200V 970 r.p.m.
Screwdown cascade exciter set	Screwdown generator exciter, *SGE1*, 2·15kW	Pilot exciter for *SGE1*, 2·15kW	Screwdown generator exciter, *SGE2*, 2·15kW	Pilot exciter for *SGE2*, 2·15kW	40 h.p. 460V 1450 r.p.m.

* As shown in Fig. 6, the machines are connected in cascade thus :
Exciters *GFE*, *ME1* and *PE1* for the excitation of the Ilgner generator.
Exciters *ME2* and *PE2* for the mill motor exciter, *MFE*.

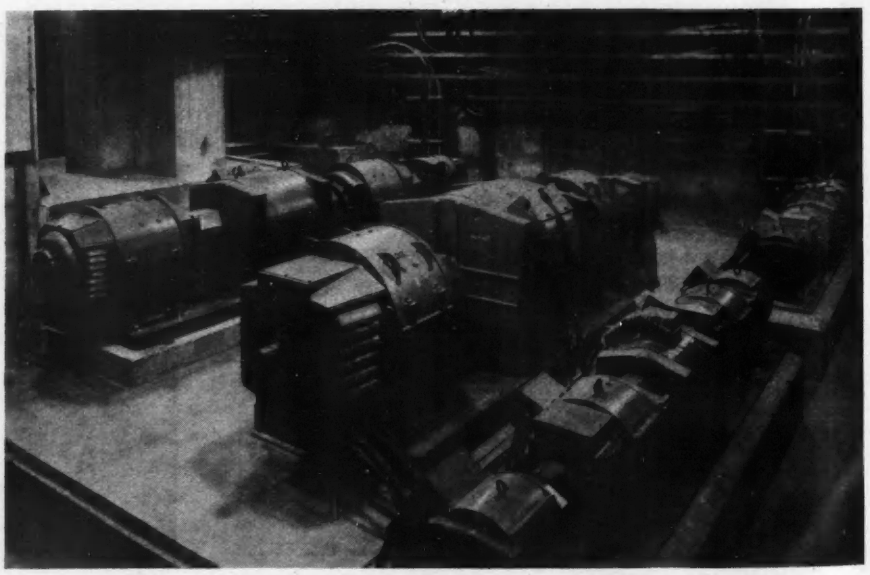


Fig. 5—Motor Generator and Cascade Exciter Sets

being such that the slip is limited to 10 per cent at the full-load torque of the motor. A 1½ h.p. pump circulates the electrolyte and the liquid starter is operated by a d.c. motor fitted with limit switches and interlocking contacts.

Control System

The cascade exciter control scheme used for the main mill and screwdown drives is a method of energising the field of a large generator in such a manner that the excitation can be varied and, if necessary, reversed, in the minimum of time and by the expenditure of a very small amount of electrical energy in the initiating circuit. The cascade exciter scheme is used in conjunction with Ward-Leonard control and is applied to the fields of the generators which supply the main driving motors.

To change or reverse a large field quickly, an exciter giving a maximum voltage of up to six times the normal field voltage is required and such an exciter requires appreciable power in its own field circuit. By using a pilot exciter to provide the excitation of the main exciter, the power required to initiate a change in the main generator field is reduced and, if the pilot exciter is also designed to give a far higher voltage than is normally required, a rapid response is obtained. To ensure this rapid response both exciters must have completely laminated iron circuits and two additional field windings must be provided on the pilot exciter to prevent hunting; otherwise they are standard d.c. machines.

Hunting is prevented by connecting one of the additional windings on the pilot exciter across the output of the main exciter and the other in series with the armature of the main exciter. Under steady conditions the windings neutralise each other and there is no resultant effect on the field. When the current in the main generator field is changing the pilot fields are unbalanced by the inductance of the generator field and an extra magnetising force is applied to the exciter field which has the effect of preventing the system from hunting.

For controlling the main mill motor, which has an armature weighing 58 tons, there are three exciters connected in cascade; with this system the change from full speed forward to full speed reverse can be accomplished in five and a half seconds, the corresponding time for base speed forward to base speed reverse being two seconds.

A simplified schematic diagram of the main control circuit is shown in Fig. 6. The mill motor is connected in a closed loop circuit with the three generators, the fields of which are connected in parallel and are energised by a generator field exciter *GFE*. The connection between this exciter and each generator field is made by a "suicide" contactor *SC*, and when the machines are stopped this contactor also connects the field windings to the armatures of the generators to prevent circulating currents and "creeping."

The exciter *GFE* is excited from the main exciter *ME*1, which in turn is excited from the pilot exciter *PE*1, which has four field windings, *B*1, *C*1, *A*1 and *D*1. The windings *B*1 and *C*1 are arranged to receive current and voltage signals from the succeeding stages of the cascade system and their function is to stabilise the system. The control winding *A*1 receives a voltage which is the difference between a reference voltage selected by the master controller and a suitable fraction of the generator voltage. At steady speed the small difference between these voltages is sufficient to produce the required generator excitation. The winding *D*1 is arranged to provide current limiting and opposes or assists winding *A*1 when rapid changes in the reference voltage would otherwise cause overcurrents in the main loop circuits.

The mill motor is excited by a motor field exciter *MFE* which is excited by a main field exciter *ME*2, this in turn being excited by a pilot exciter *PE*2. The exciter *MFE* has two field windings *A* and *B*, of which *A* provides the maximum field current required for the main motor. The winding *B* is excited by the pilot exciter *ME*2 and opposes *A* to provide the reduction in the main motor field required to give maximum speed and also the forcing necessary to ensure rapid response to a control signal.

The pilot exciter *PE*2 has four field windings *C*2, *B*2, *A*2 and *D*2. Of these windings, *C*2 and *B*2 are stabilising windings and *A*2 receives the difference between a reference voltage selected by the master controller and a voltage derived from a tachometer generator *TG*1. At steady speed the small difference between these voltages is sufficient to reduce the excitation of *MFE* and hence of the motor, to the value required by the position of the master controller. The winding *D*2 is arranged to provide current limiting which is similar to that provided by winding *D*1 on exciter *PE*1 and is described in detail below.

The rectifier systems *R* and *R*1 in conjunction with the current limit selector *E* and windings *D*1 and *D*2 of the pilot exciters, limit the maximum current passing in the main loop circuit in the following manner. Below the basic speed of

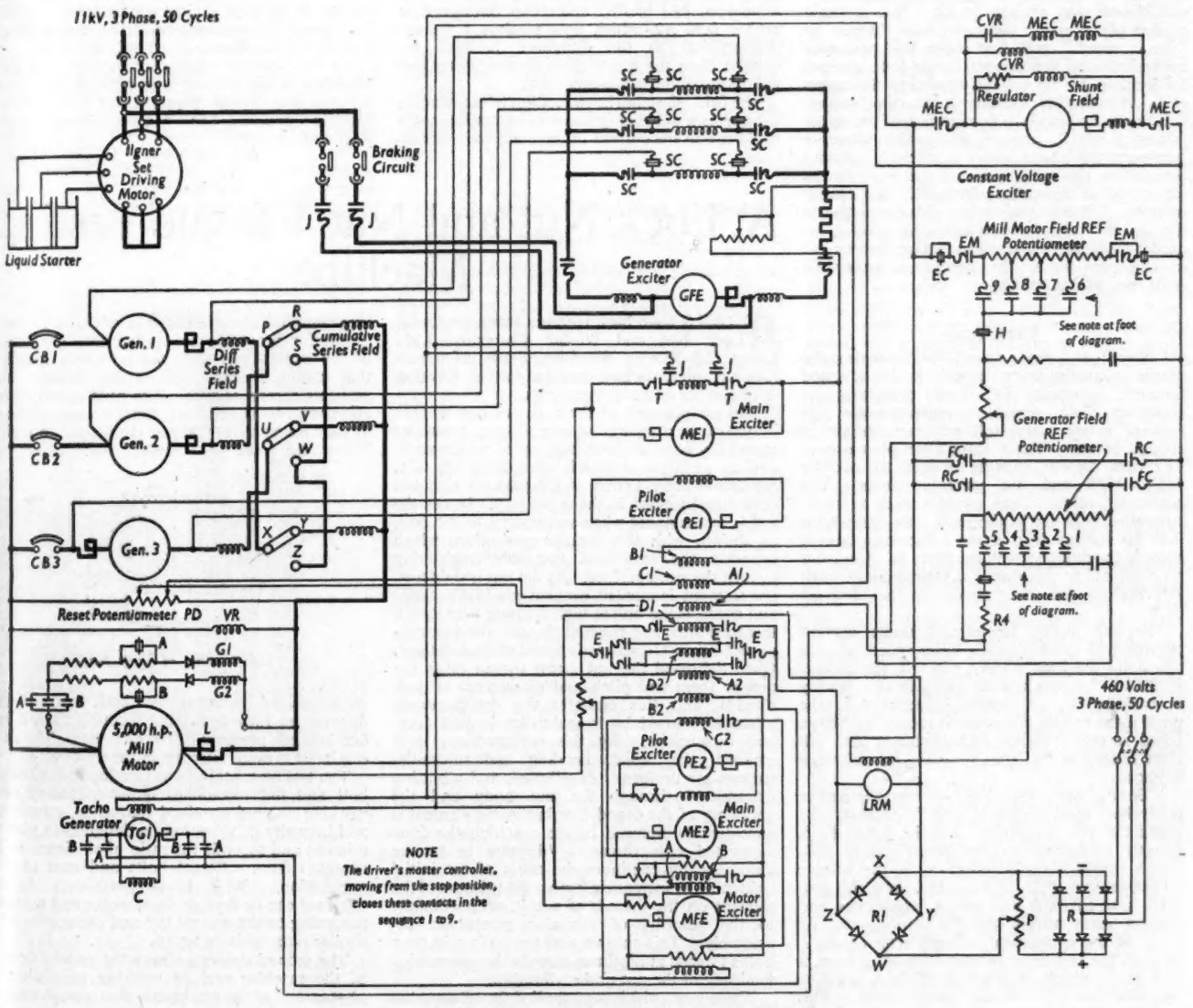


Fig. 6—Simplified Schematic Diagram of Main Control Circuits

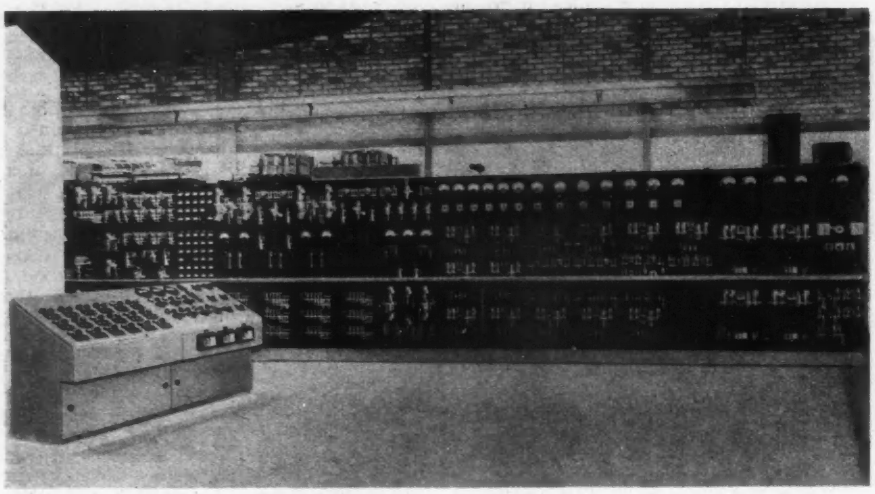


Fig. 7—Control Desk and Contactor Switchboard in Motor Room

50 r.p.m. the contacts *E* connect *D* in series with the main motor interpole and compensation windings to the points *Y* and *Z* of the rectifier *R*1. The points *WX* of this rectifier are supplied with an adjustable voltage from potentiometer *P* which is energised by rectifier *R*.

As long as the voltage across *WX* exceeds the voltage drop across *L*, no current can pass through winding *D*1. If the main loop current increases until the voltage across *L* exceeds that across *WX*, a current will pass through *D*1 and will oppose any change in *A*1. Thus a rapid motion of the master controller from "zero" to "basic speed" will first raise the generator excitation until the current in the loop exceeds the limit set by the voltage applied to the points *WX*. Any further increase in the pilot voltage will be checked until the acceleration of the motor causes a fall in line current; this sequence continues until basic speed is reached. During retardation the main loop current controls the rate of fall of the voltage from *PE*1 in a similar manner. During acceleration above basic speed the current limit is transferred by relay *E* to exciter *PE*2, where it acts in a similar manner but in opposite sense, the generator meanwhile remaining at full voltage.

Operation

"*Stop*" *to* "*Basic Speed.*"—On moving the master controller from "stop" to "basic speed forward," contactor *FC* closes, energising the generator field reference potentiometer for forward running and full reference voltage is applied to *A*1. The voltage from pilot exciter *PE*1 rises rapidly, exciting in turn the exciters *ME*1, *MFE* and the generator fields. The generator voltage rises rapidly and a heavy current is built up in the main loop circuit, so that the voltage drop across *L* increases until it exceeds the reference voltage from *R*. A current proportional to this excess will circulate through *D*1, keeping the loop current to the limit set by *R*.

The mill motor accelerating under current control will quickly reach basic speed, and at this point the loop current will fall, the current in *D*2 will be zero and the mill will run steadily at basic speed. A similar sequence will take place if the master controller is moved to "basic speed reverse," except that contactor *RC* will close instead of *FC*, thus reversing the reference voltage.

"*Basic Speed*" *to* "*Stop.*"—When the master controller reaches the "stop" position the contactor *FC* is opened and the field *A*1 is directly connected to the potentiometer *PD*, which causes a rapid reduction in the voltage of the exciters *PE*1, *ME*1, *MFE* and the generators, so that the mill motor regenerates and feeds a heavy current into the loop circuit. As soon as the consequent voltage drop across *L* exceeds the reference voltage from *R*, a current will pass through the winding *D*1 in a direction opposite to that during acceleration. This current will, therefore, oppose the voltage from *PD*, keeping the generator voltage up and limiting the regenerated current to the preset figure. Finally, the falling generator voltage releases relay *VR*, which in turn releases *SC* and makes the "suicide" connection.

"*Stop*" *to* "*Full Speed.*"—Acceleration up to basic speed takes place as previously described. The relay *G* then closes and in turn closes relay *A*, which selects the correct polarity of tacho-generator *TG*1 for forward running and then closes contactor *E*. This transfers the current limit from *PE*1 to *PE*2 and closes the circuit of exciter field *A*2, which now receives a voltage proportional to the difference between the voltage from the motor field potentiometer and the output of the tacho-generator.

The field *A*2 acting in opposition to the winding *D*2 causes a weakening in motor excitation and a rapid rise in the current in the main loop circuit, which brings into operation the current limitation previously described.

"*Full Speed Forward*" *to* "*Stop.*"—When the master controller is moved to "stop" both reference potentiometers are disconnected and the contactor *FC* is held closed so that full reference voltage is maintained for generator control. The motor reference voltage is meanwhile reduced to zero and the tacho-generator *TG*1 is short-circuited through the pilot exciter field *A*2. This gives the maximum "lower speed" signal to the motor exciter system, so that the motor field is strengthened at a rate controlled by the current limit.

At basic speed the relay *C* opens, in turn opening the relays *A* and *E* and so reconnecting field *A*1 to its reference potentiometer, which is at zero. The maximum "lower voltage" signal is given to *A*1 and this generator field is then rapidly weakened under current limit control, which has been restored by the opening of *E*. Finally, at low voltage, the contactor *SC* makes the suicide connection under the control of voltage relay *VR*.

"*Full Speed Forward*" *to* "*Full Speed Reverse.*"—Contacts on the master controller disconnect exciter field *A*2 from the reference potentiometer and by short circuiting the tacho-generator through *A*2 cause the maximum "lower speed" signal to be given to exciter *PE*2. The motor field is thus rapidly strengthened under current limit control. The generator field is unaffected until the relay *C* opens at basic speed, in turn opening *A*. The contacts *RC* are then closed, thus reversing the reference potentiometer, and the limiting resistance *R*4 is introduced into the reference circuit to avoid an unduly heavy signal to the exciter field *A*1. This field receives the maximum "lower speed" signal and rapidly reduces the exciter voltage under current limit control. Acceleration in the reverse direction then takes place as previously described.

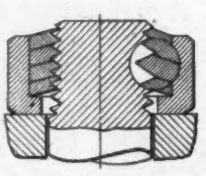
All the electrical equipment for the main and auxiliary drives of the cogging mill described in this article was supplied by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2.

A Lock Nut and Nut Fatigue Testing Machine

DETAILS have been received from the Lester Lock Nut and Washer Company, Ltd., Camp Hill Works, Wordsley, Staffs, of a new lock nut and a machine designed for the vibration testing of nut and bolt assemblies.

The arrangement of the lock nut can be seen in one of the drawings we reproduce. It consists essentially of an element built up of a number of conical metal discs which after assembly in a hexagonal body, known as the pressure ring, are drilled and tapped in the usual way. In use the nut is free-running when screwed on to the bolt, as shown, with the annular projection, which supports the laminated assembly, registering against the work surface. As the nut is tightened the screwed laminated element gradually closes and contacts the bolt at high pressure over its full threaded area, and the bolt threads are thus supported against deformation and thread fatigue. Once tightened the nut screw thread takes the precise form and pitch and dimensions of bolt threads, and this obviates the disadvantages otherwise caused by irregularities in bolt form and dimensions. By this construction, it is claimed, the radial, bending and tangential stresses are uniformly distributed, and vibration transmitted through the nut body and the periphery of the coned disc laminated element is considerably reduced before reaching the fully supported bolt thread. Vibration in service automatically continues the effect of the initial tightening by increasing further the pressure of the element on the threads of a bolt, proportionally to the intensity of vibration present in the assembly. This ensures that the nut's grip on a bolt's threads at all times exceeds the unscrewing tendency of the nut under vibration.

These nuts, which are supplied for all qualities and sizes of bolts and studs, are stated to have a large number of advantages in addition to their "vibration-proof" locking properties. The action of the laminations seals out corrosive agencies that could otherwise act on the threads, and prevents thread seizure. The nuts can be used effectively on rough and uneven work seatings as they automatically adjust themselves to maintain a full thread engagement. Bolt threads are



Construction of Lock Nut

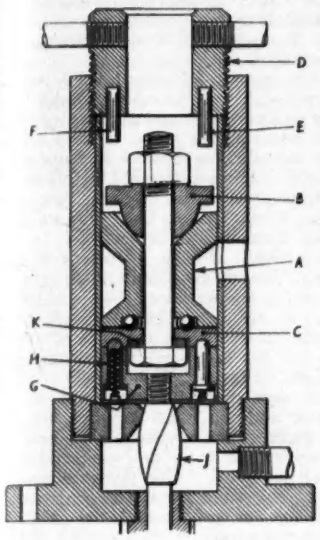
not depressed by the nuts as both flanks of the threads are fully supported through the wedge-like inwards pressure of the elements. The nuts can be unscrewed after use in the usual way.

The testing machine was developed for testing bolt and nut assemblies under vibration and, working at predetermined frequency, amplitude and intensity of vibration, is designed to give in minutes and seconds the ratio of efficiency to be expected from different bolts and nuts in any application. With it the efficiency figures obtained can be read as days, weeks and months, according to the present use and experience with similar nuts to those tested.

The second drawing shows the general layout of the machine and its working principle; a photograph of the machine is also reproduced on page 285. It consists essentially of a pneumatic

cylinder in which a reciprocating piston carries the nut bolt assembly to be tested.

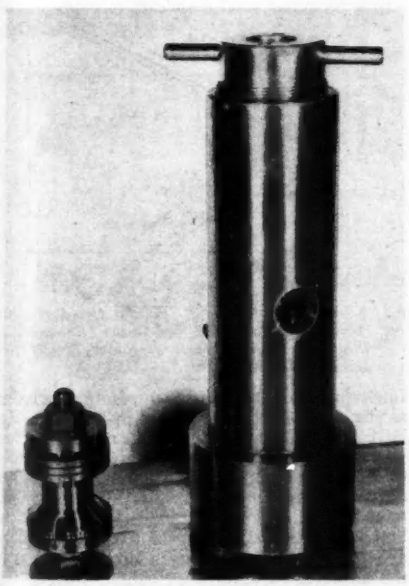
The piston assembly consists of the main body *A* through which the bolt is passed and locked by the nut between a rocker head *B*, carried in a hemi-spherical seating in the top, and a separate flange *C*, mounted on a ball-bearing thrust washer, at the bottom. This piston assembly, to be seen by the machine in our illustration, is put into the cylinder of the unit and the head *D* screwed on to seal against the top of the cylinder



Arrangement of Nut Fatigue Testing Machine

liner. Two pins project downwards from the cylinder head, one, *E*, being a striker pin, and the other, *F*, a shorter check pin, which serves to control the tilt of the piston rocker head when the nut starts to loosen under test.

Through an adapter at the lower end the cylinder is directly coupled to an air compressor running at 712 r.p.m. Through this direct coupling a similar number of impulses are given



Nut Testing Machine and Piston Assembly

to the test unit piston, which therefore hits the striking pin 712 times a minute whilst the compressor is working. At the base of the cylinder is a second piston *G*, which, through spring-loaded driving pins *H*, and a twisted shank *J*, imparts a turning movement to the main piston when it is returned by air suction to the bottom of the stroke. The four spring-loaded driving pins fitted are offset to prevent the piston being hit repeatedly in the same place with each revolution. The main piston is rotated at about 20 r.p.m. in one direction whilst it is reciprocating.

A hardened washer *K* in the main piston assembly has a definite friction area to eliminate variations in torque readings due to varying bolt head contact surfaces. Similarly, the base of the nut contacts a fixed diameter raised annular area on the top of the rocker head. The ball bearing between the lower part of the piston and the flange also serves to provide a constant friction area.

When the main piston carrying a nut and bolt assembly is reciprocating in the cylinder and the rocker head hits the striking pin, a tilting motion is imparted to the head. This gives the nut on the side opposite to the striking pin a load additional to that imparted by the original tensioning upon assembly. At the same time, there is a proportional decrease in the load on the side of the nut nearest the striking pin. An alternating bend test to the bolt is thus obtained simultaneously. As the testing cycle is continued the rapid loading and unloading is repeated around the full circle of the nut base area some 712 times a minute, during which time the piston makes approximately twenty revolutions.

It will be appreciated that in order to make comparative tests it is necessary to use a torque wrench when assembling bolts and nuts on the piston. By marking the nut and bolt at an initial tightening any movement of a nut in relation to its bolt can, if required, be easily observed at any time during a test. The construction of piston makes it possible at the start and at any time during a test to establish bolt load and thereby rate at which this load is lost under vibration.

The machine can be used to test a wide range of nut and bolt assemblies and with it the makers have carried out comparative tests with "Lester" and other forms of nuts. Details of these tests and their results are obtainable from the manufacturers.

A Cemented Chromium Carbide

(By Our American Correspondent)

THE unusual combination of properties exhibited by Grade 608 Chrome Carbide, the first of a series of cemented chromium carbides developed by the Carboloy Department of the American General Electric Company, is expected to lead to wide application of the new metal. Grade 608 Chrome Carbide is said to have extremely high resistance to both corrosion and erosion, and to have good abrasion resistance. Made by the powder metallurgy process, the metal is light, has a coefficient of thermal expansion approximately the same as that of steel, is completely non-magnetic and has extreme resistance to high temperature oxidation. The metal is composed of 83 per cent chromium carbide, 2 per cent tungsten carbide and 15 per cent nickel. Among its outstanding physical properties are its density, which is about half that of tungsten carbide, and its coefficient of thermal expansion. Salt spray tests, which were conducted at the Battelle Memorial Institute, have shown that cemented chromium carbides retain their metallic lustre after being subjected to a 30 per cent salt spray for 750 hours. When subjected to sulphuric acid corrosion tests, they showed thirty times the resistance of 18–8 chromium-nickel stainless steels and three times the resistance of conventional carbides. The resistance of chromium carbides to nitric acid has been found to be eight times that of other carbides and twice that of 18–8 stainless steels. High temperature tests have shown that the chromium carbides resist oxidation at all temperatures up to 1830 deg. Fah. When subjected to a temperature of 1850 deg. Fah. for twenty-four hours samples of chromium carbide are only slightly discoloured, while simultaneously exposed samples of stainless steel and tungsten carbide have completely disintegrated. Steam erosion tests show a resistance for chromium carbides about fifty times that of conventional carbides. Samples 1½in in diameter and 0·250in thick were placed ¼in in front of a jet of saturated steam at 350 lb per square inch passing through a $\frac{1}{16}$in diameter nozzle for periods of twenty-five hours. Four tests of twenty-five hours each, made with identical nozzle assemblies, show no measurable erosion penetration on the chromium carbide samples after the first three tests. The average penetration effected after the first 100 hours is 0·0004in.

Grade 608 Chrome Carbide is already available in the United States in limited quantities in a variety of shapes for engineering and metallurgical test applications, and production facilities are being expanded. When these production facilities are completed, the new carbide will be available in approximately the same size and shape range in which tungsten carbide is now being offered. Because the costly and scarce tungsten and cobalt are not constituents of the new material, it is expected that complete parts can be economically made of solid chromium carbide instead of attaching individual pieces, as has been done with tungsten carbide in the past; the light weight of chromium carbide is another factor in favour of this design concept. Generally the same methods used in fabricating tungsten carbide are used for chromium carbide.

Components can be moulded to shape for standard or quantity parts. They can also be economically machined to required shapes in the presintered condition for small-lot production. Grinding, lapping and polishing of chromium carbide is performed with conventional silicon carbide grinding wheels, diamond grinding wheels and diamond lapping compounds. Polished surfaces of chromium carbide have a more brilliant lustre than those of tungsten carbide. Chromium carbide can be attached by brazing, by mechanical means or by thermo-setting resin cements. It is necessary to flash-plate chromium carbide parts with nickel for brazing with conventional materials. The results of recent tests with ethoxyline resins as a bonding agent for attaching chromium carbide to non-porous materials like metals have been very encouraging. Bond strengths of the ethoxyline resin cemented joints at room temperature are much lower than brazed joints but approximately equal to those of soft soldered joints. In general, resin-cemented joints can be used in place of brazed joints where high strengths are not required and when the application operates at room or slightly elevated temperatures. Bond shear strengths of from 5000 lb to 8000 lb per square inch at room temperature have been obtained with ethoxyline cements of several manufacturers using various curing methods. At 200 deg. Fah. bond strengths decrease to a half of the above values. Prolonged immersion in water has been found to weaken the bond about 15 per cent. Carbide parts that have been attached by ethoxyline resin cements can be removed by heating the joint to 600 deg. Fah., at which temperature the cements decompose and the parts can be prised loose easily. The charred cement can be removed by sanding or scraping.

The excellent corrosion and erosion resistance of Grade 608 Chrome Carbide, combined with good abrasion resistance, are expected to suggest many successful applications in industry. In the chemical field its resistance to acids and sodium hydroxide indicates that nozzle and control valve components are likely applications. In the pharmaceutical and food processing industries, the carbide may also find applications in valves and nozzles because of its resistance to citric and lactic acids. Scraper blades for centrifuges and seal rings for homogenising equipment are other suitable applications. Because chromium carbide has about the same thermal expansion coefficient as steel it is finding wide application in the gauge manufacturing field, where wear resistance of gauging surfaces and temperature expansion are important considerations. The corrosion resistance of chromium carbide gauging surfaces is also a factor in prolonging gauge surface life. Mechanical parts for all kinds of machinery that must resist wear, corrosion, high temperatures or erosion also are a major field of application for the new carbide.

Metallurgical Topics

Superheater Tubing

WHEREAS 500 deg. Cent. was considered to be a satisfactory maximum temperature in central station boiler plants a few years ago, with steam temperatures advancing to 560 deg. Cent. in new installations to-day, and with indications that steam temperatures of 650 deg. Cent. or more will be utilised in the not too distant future, the selection of suitable materials for superheater and reheater tubing requires special consideration. Alloys with good service characteristics in the range 600 deg. to 730 deg. Cent. are required to meet steam conditions which may obtain in the future. While the mechanical properties of such alloys are not too serious a problem, the matter of corrosion resistance is a critical one. Recognising the importance and the complexity of the corrosion problem, the American Society of Mechanical Engineers, through its Research Committee on High-Temperature Steam Generation, has undertaken the sponsorship of a comprehensive investigation to evaluate commercially available alloys for their suitability as superheater and reheater tubing at metal temperatures up to 730 deg. Cent. The programme of the committee is divided into two main parts. One is concerned with the reaction of high-pressure, high-temperature steam on such materials. The other deals with the corrosive effect of flue gases and fuel ash on the external surface of the tubes. This again is subdivided into two parts. The specific object of the first part is the evaluation of the alloys with respect to resistance to corrosion or scaling by the products of combustion of the various fuels used in boilers under actual conditions of service. The other part comprises laboratory investigations, carried out mainly at the Battelle Memorial Institute, on the effect of certain components of a combustion atmosphere on the rate of corrosion of the same alloys. The first part of the programme is the subject of an interim report by F. G. Ely and F. Eberle.[1] A test element was constructed of 2in outside diameter alloy tubes and installed in an operating boiler supplied with steam at 2000 lb per square inch and 510 deg. Cent. which was heated to 675 deg. Cent. Operating conditions and the results of the first 5000 hours' service are described in the paper. It is too soon for any definite conclusion to be reached, but there are indications that it should be practicable to construct commercial steam superheaters to operate in the range 2000 lb per square inch and 650 deg. Cent. Armco 17–14–CuMo and type 316 (see Table I) appeared to be attacked by steam to a slightly greater extent than types 304, 321, 347 and 318.

TABLE I—*Percentage Composition of Materials Tested*

Type	Ni	Cr	C	Mn	Si	Mo	
16–25–6	24·8	16·3	0·08	1·7	0·34	5·95	0·146 N_2
309S	13·8	23·7	0·09	1·4	0·58	0·03	0·132 N_2
310	20·3	25·2	0·08	1·7	0·75	0·02	—
347	11·1	17·2	0·06	1·6	0·58	0·02	0·73 Nb
308	10·0	20·8	0·06	2·0	0·38	0·24	—
309	14·54	23·12	0·13	2·0	0·40	0·15	—
314	21·45	24·56	0·09	1·3	2·20	0·13	—
321	10·36	17·72	0·07	1·4	0·47	0·15	0·45 Ti
304	10·18	18·86	0·07	1·61	0·35	—	—
316	13·42	11·32	0·08	1·66	0·45	2·36	—
318	14–96	17·17	0·07	1·62	0·51	2·03	0·72 Nb
17–14–CuMo	26·42	16·18	0·08	1·64	0·45	6·4	—
Inconel	70 (min.)	11–15	0·15 (max.)	1·0 (max.)	0·5 (max.)	—	Fe 10 (max.)
Illium G	58	22	—	1·2	0·4	6·0	Fe 6

Remainder iron except where iron content is stated. Aluminised mild steel was also included in external corrosion tests.

The tests for external corrosion are somewhat further advanced and were reported by H. A. Blank, A. M. Hall and J. H. Jackson.[2] Fourteen commercially available alloys were selected for evaluation in the form of 1in diameter bars (Table I). The austenitic iron-base alloys were solution heat-treated by water quenching after heating for two hours at 1120 deg. Cent., and the others were tested in the hot-rolled condition. Specimens of each were placed in specimen racks suitably installed in the superheaters of the steam generating plant of ten different companies; seven were public utility companies, one a steel company, one an oil company and one a merchant ship. Wide differences in corrosiveness occurred among the atmospheres produced by the combustion of the various kinds of fuel used for steam generation in the plants selected. With this in mind, results were examined in detail, allowance being made for different cycles of temperature fluctuations at different plants during the test and for spread in the average temperature. In the tests reported in the paper, low-sulphur coal and gas produce combustion products which are only mildly corrosive. High sulphur, high alkali and high vanadium in the fuel, on the other hand, produce combustion products which are extremely corrosive towards metals. The general degree of corrosiveness seemed to be related to the sulphur, vanadium and alkali metal content of the fuel. Excluding considerations of strength and resistance to internal corrosion by high-pressure steam, it may be said that under mild corrosion conditions a variety of alloys is available for superheater tubing to operate at metal temperatures up to 730 deg. Cent. without appreciable external attack. Under very corrosive conditions all the alloys tested were corroded. Under the severe conditions produced by No. 6 fuel oil, 17–14–CuMo and 16–25–6 were completely corroded away. Both these contain comparatively large amounts of molybdenum, and were the worst of the series. Types 309S and 310 were the best, while 308, 309, Inconel and Illium G were better than the others. In a high-sulphur atmosphere from 82 per cent oil, 18 per cent gas, 17–14–CuMo and 16–25–6 were again completely corroded away, while types 316, 321, 304 and Inconel were inferior to the rest. In a less corrosive atmosphere from coke and blast-furnace gas, Illium G showed extensive sub-surface attack. Types 309, 309S, 310, 314 and 347 showed a better overall resistance than the others, but 310 suffered some sub-surface attack, and 309S, 310 and 314 showed slight pitting. On the whole, type 314 showed the best result in these circumstances. Taking all results into consideration, the authors concluded that types 309S, 310 and 314 usually showed the best resistance to both general corrosion and to sub-surface attack. The laboratory work at the Battelle Institute is not yet completed and will be the subject of a future paper.

[1] "Experimental Superheater for Steam at 2000 lb per square inch and 1250 deg. Fah.: Progress Report of Field Operation," *Trans. A.S.M.E.*, July, 1952, page 803.
[2] "Behaviour of Superheater Tubing Materials in Contact with Combustion Atmospheres at 1300 deg. Fah.," *Trans. A.S.M.E.*, July, 1952, page 813.

Low-Temperature Properties of Ingot Iron

A VERY thorough examination of the tensile properties of ingot iron at low temperatures was made by G. W. Geil and N. L. Carwile[1] in 1950. True stress-strain curves were presented showing the influence of the testing temperature, the ferrite grain size, the initial condition of the iron and other factors on the work-hardening characteristics of the material. This work has now been extended by the same authors[2] in an investigation to determine the effect of the strain-temperature history of ingot iron on the true stress-strain relationship of specimens extended in tension at temperatures ranging from −196 deg. to +100 deg. Cent. Specimens of ingot iron in different conditions of treatment were extended in tension to specified true strain values at selected temperatures, and subsequently extended to fracture at different temperatures. The true stress-strain values obtained in these two-stage tests were compared with those obtained in single-stage tension tests at the same temperatures.

The ingot iron contained 0·02 per cent of carbon and lower amounts of other elements except oxygen 0·058 and copper 0·10 per cent. It was tested as hot rolled, as cold drawn, and in the annealed, normalised and quenched and tempered conditions obtained as follows:—

Annealed: 0·875in diameter rod, heated at 950 deg. Cent. for one hour, furnace cooled to 425 deg. Cent. then air cooled.

Normalised: 0·875in diameter rod, heated at 950 deg. Cent. for one hour and air cooled.

Quenched and tempered: 0·5in diameter rod, heated at 925 deg. Cent. for half hour and quenched in iced brine, then heated at 720 deg. Cent. for one hour and furnace cooled to 37 deg. Cent. in forty-five hours.

Tests were made on specimens of 0·438in diameter and 2in gauge length. In the two-stage experiments, about half an hour elapsed between the end of the first stage and the beginning of the second. The figures illustrating the present review are simple diagrammatic representations of parts of some of the detailed curves given in the paper.

ANNEALED INGOT IRON

Fig. 1 shows typical behaviour of the annealed material extended in two-stage tests at 27 deg. and −78 deg. Cent. (and vice versa), together with the true stress-strain diagrams for one-stage tests at each of these temperatures. Deviation of the true stress-strain curve for the second stage of a two-stage test from the curve for a single-stage test at the same temperature increases as the amount of prestraining in the first stage increases. In general, the load on the specimen was reduced to 200 lb per square inch between the first and second stage, but the curves obtained were the same whether the full load was maintained or this reduced load was employed between stages. The behaviour of the quenched and tempered specimens was similar to that of the annealed material.

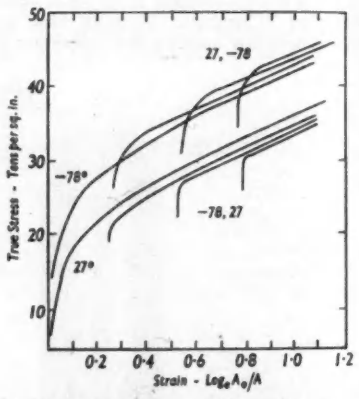


Fig. 1.—True Stress-Strain Values Obtained with Annealed Ingot Iron Specimens Extended in Two-Stage Tension Tests at Room Temperature and at −78 Deg. Cent.

NORMALISED INGOT IRON

With normalised specimens, the effect of prestrain on the strength was also similar (Fig. 2) but the ductility, to which reference will be made later, was affected quite differently. A prestrain at room temperature greatly increased the ductility at −78 deg. Cent., as indicated by the fracture strain of approximately 1·1 for the two-stage test, and of approximately 0·5 for the single-stage test at −78 deg. Cent. On the other

hand, prestrain at −78 deg. Cent. reduced the ductility retained at room temperature.

Hot-Rolled Ingot Iron

Hot-rolled specimens behaved similarly to the normalised material (Fig. 3). Prestraining at room temperature approximately to maximum load improved the ductility retained by the steel at lower temperatures; and the fracture strains of the specimens in the two-stage tests were greater than those of specimens fractured in single-stage tests at the same low temperature. A specimen of hot-rolled ingot iron was prestressed in tension at 100 deg. Cent. to a strain slightly beyond the maximum load and then extended to fracture at −78 deg. Cent. The strain ageing of this specimen after deformation at 100 deg. Cent. was much greater than that of specimens deformed at room temperature; and the elevation of the stress-strain values after

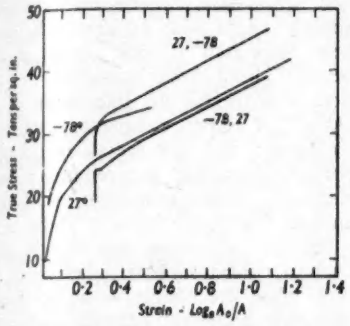


Fig. 2.—True Stress-Strain Values Obtained with Normalised Ingot Iron Specimens Extended in Two-Stage Tension Tests at Room Temperature and at −78 Deg. Cent.

this treatment above the curve for the single-stage test at −78 deg. Cent. is much greater than for the specimens prestrained at room temperature, but the fracture strain was little greater than in the single-stage test.

Work Hardening

Plastic straining results in work hardening, which is due in varying degree to strain hardening and strain ageing. Work hardening relates to the increase in true stress with true strain, and is the combined effect of strain hardening and strain ageing. Strain hardening refers to that portion of the hardening or strengthening of the

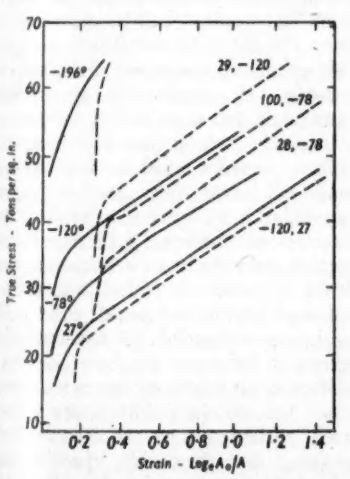


Fig. 3.—True Stress-Strain Values Obtained with Hot-Rolled Ingot Iron Specimens Extended in Two-Stage Tension Tests at Different Temperatures.

metal during plastic deformation that is not dependent on time but occurs concurrently with strain, whereas strain ageing refers to that portion of the hardening or strengthening which may proceed during or subsequent to plastic deformation, but which is dependent on time and can occur only as a result of previous strain and not concurrent strain. The work hardening of ingot iron during deformation in tension at temperatures below −120 deg. Cent. is mainly strain hardening, and increases with lowering of the testing temperature. As the temperature is raised above −120 deg. Cent. the influence of strain ageing during the deformation increases. Even at −78 deg. Cent. the work hardening due to strain ageing is approximately equal to the increase in strain hardening that occurs as the testing temperature is lowered from −78 deg. to −196 deg. Cent. At 100 deg. Cent. the effect of the strain ageing is at least equal to or greater than that of the strain hardening. The authors consider that the data contained in this and the previous paper show that strain ageing of ingot iron is a very important factor affecting the true stress-strain relationship at temperatures as low as −120 deg. Cent. This conclusion is contrary to the generally prevailing belief that the strain ageing of ingot iron is insignificant at sub-zero temperatures.

Rheotropic Embrittlement

E. J. Ripling and W. M. Baldwin, Jr.,[3] in a report of the phenomenon that they called "rheotropic embrittlement" of steel, concluded that a large part of the deficiency in ductility of annealed steels at low temperatures was "rheotropic," or responsive to plastic flow, and could be removed by prestraining under more ductile conditions at higher temperatures. The data obtained by Jenkins and Digges on annealed ingot iron, however, indicate that the low-temperature embrittlement of this material is not rheotropic in the manner proposed by Ripling and Baldwin. Prestraining of the annealed iron at room temperature reduced rather than increased the ductility retained at −154 deg. or −196 deg. Cent. The embrittlement due to strain ageing during the prestraining at room temperature is believed to be the main cause for the loss in the retained ductility at these low temperatures. On the other hand, the brittleness at −78 deg. Cent. or at lower temperatures of normalised or hot rolled ingot iron is sensitive to, and in part curable by, prestrain under ductile conditions at higher temperatures. After prestrain at room temperature, the ductility retained by the specimens in subsequent extension in tension at low temperatures is increased (Figs. 2 and 3). At −120 deg. Cent. the fracture strain was increased from 1·02 to 1·25. The fracture strain at −78 deg. Cent. of the hot-rolled specimen prestrained at 100 deg. Cent. was about equal to that of the specimen extended to fracture in a single-stage test at −78 deg. Cent., but was considerably less than that of the specimen prestrained at room temperature and extended at −78 deg. Cent. The additional embrittlement of this specimen by the greater amount of strain ageing during deformation at 100 deg. Cent. was apparently about equal to the rheotropic embrittlement during the deformation of a specimen to the same strain in a single-stage test at −78 deg. Cent. The amount of strain ageing and the rheotropic brittleness of specimens of ingot iron vary with the heat treatment and prestraining history of the specimens; and the effect of prestraining ingot iron at room temperature on the rheotropic embrittlement of specimens at lower temperatures depends greatly on the initial condition of the iron.

[1] U.S. National Bureau of Standards, *Journal of Research*, August, 1950, Vol. 45, page 129.
[2] *ibid.*, June, 1952, Vol. 48, page 399.
[3] *Trans. American Society for Metals*, 1951, Vol. 43, page 778.

Tensile Properties of High-Purity Nickel

At the U.S. National Bureau of Standards, W. D. Jenkins and T. G. Digges[1] have carried out tensile tests at temperatures ranging from −196 deg. to 815 deg. Cent. on specimens of hot-worked and annealed nickel of 99·85 per cent purity. The test pieces had a diameter of 0·505in and a gauge length of 2in, and the rate of extension beyond the yield point was about 1 per cent per minute.

Results are shown in Figs. 1 and 2. The general trend was for the 0·2 per cent yield strength and the tensile strength to decrease, and the reduction of area to increase, with increase in testing temperature. There were, however, some anomalies, especially in elongation. This passed through a minimum in the range 25 deg. to 150 deg. Cent., and again at about 260 deg. Cent., and showed considerable irregularity above 550 deg. Cent. A strain-ageing effect was observed in specimens tested at temperatures between 25 deg. and 150 deg. Cent., attaining a maximum in the upper part of this range. There was no evidence of recrystallisation taking place below 530 deg. Cent., though slight softening occurred at that temperature. Recrystallisation became clearly evident in tests made at 650 deg. Cent.

Average results of tests at room temperature and at 100 deg. Cent. were as follows:—

	25 deg. Cent.	100 deg. Cent.
0·2 per cent Yield Stress, tons per square inch	5·6	5·5
Maximum Load, tons per square inch	23·3	21·6
Elongation, per cent on 2in	56	57
Reduction of area, per cent	88	88

The strength was thus intermediate between that of pure annealed nickel (99·99 per cent) and annealed wrought commercial nickel (99·4 per cent), of which the 0·2 per cent yield strengths

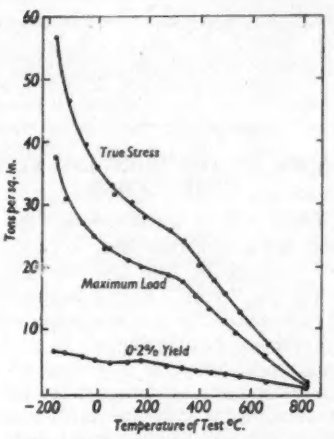


Fig. 1—Effect of Temperature on the tensile properties of hot-worked and annealed Nickel (Jenkins and Digges).

are respectively 4 and 9 tons per square inch, and the maximum loads 20·3 and 31·0 tons per square inch[3]. The strength was lower and the elongation higher than those given by the Mond Nickel Company[3] as typical of commercial hot-rolled and annealed nickel, thus further illustrating the influence of purity of the metal on its tensile properties. In short-time tensile tests on this material (nickel 99·5 per cent) the tensile strength rose from 33 tons per square inch at room temperature to 37 tons per square inch at 320 deg. Cent., and then fell somewhat rapidly above

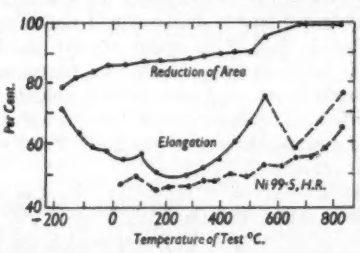


Fig. 2—Effect of Temperature on Elongation and Reduction of Area of Hot-Worked and Annealed Nickel (Jenkins and Digges): also on Elongation of Hot-Rolled Nickel (Mond Nickel Company).

500 deg. Cent. The effect of temperature on elongation in these tests is shown by the dotted line in Fig. 2. Its smoothness contrasts with the irregularities of the Bureau of Standards curve. Jenkins and Digges put forward explanations of some of these abnormalities, though it would seem that the possibilities of experimental error, dependent on material or rate of strain, should not be excluded.

References

[1] U.S. National Bureau of Standards, *Journal of Research*, April, 1952, vol. 48, page 313.
[2] C. J. Smithells, "Metals Reference Book," page 554.
[3] *The Nickel Bulletin*, January, 1951, vol. 24, page 4.

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WORK OF THE IRON AND STEEL CORPORATION

Annual reports usually cover the work of the body concerned over a period of a year. That of the Iron and Steel Corporation for the "year" ending September 30, 1951, summarised in our last issue, achieves the distinction of referring, so far as finance is concerned, only to a period of seven and a half months. For though the Corporation came into existence on October 2, 1950, it did not become responsible "for 298 companies, employing nearly 300,000 people and representing an annual turnover of about £500 million" until February 15, 1951. The report thus records only the beginning of the work of the Corporation, work that seems destined in the not very distant future to be cut off, when scarcely begun, through the terms of a Bill likely soon to be presented to Parliament. But the record is none the less interesting because it applies to the work of a body upon which a sentence of death may soon be imposed. For, transitory as the life of the Corporation may prove to be, its work will undoubtedly influence that of its apparent heir, the Iron and Steel Board, which the Government intends to set up; and, indeed, much of the work it has begun is likely to be welcomed and continued by that new body if and when it is created.

In careful, cold sentences, the Corporation's report reveals both how it did and did not manage to co-operate with the Iron and Steel Federation. It was obvious enough when the Labour Government forced through the Act which nationalised the iron and steel industry that the relationship between the Corporation and the Federation would not be wholly easy. For, without duplicating work that the existing body was already doing very efficiently the Corporation could only discharge its functions fully by reaching a long-term agreement with the Federation. But, under the political circumstances ruling at the time, that was something that it could not do. Naturally, the Corporation wished to be represented in all the deliberations of the Federation. Just as naturally the latter body contended that, as one of the subjects for consideration by its Executive Committee must be the relations between the two bodies and as that Committee was "the principal forum at which the public and private sectors could meet," it was inappropriate that the Corporation should be represented on it. Under the highly controversial circumstances prevailing when the Corporation was created and allowing for the strong resistance of the industry to nationalisation, it is very much a tribute to the good sense and tolerance of all concerned that, in fact, as this report reveals, over a very wide field the two bodies did work amicably together in the interest of the industry for which both felt responsible. Nor is much of the work the Corporation has done likely to be wasted. There are a number of activities that are likely to have an influence continuing into the future. For instance, unification of accounting practice and of methods of keeping other records has been brought about. Again, the Corporation has made a practice of borrowing "capital" from firms that are in credit at an attractive rate of interest and lending that capital to other firms having costly developments in hand at the same rate of interest. That there has been a financial saving for the industry as a whole is the least part of the advantage of this arrangement. That advantage has really lain in the ability thus given to the Corporation to ensure a better timing of capital developments, making certain that what needs to be done first is done first, and relieving individual firms of the need to borrow from banks or the public to carry out developments. It is a service to the industry that the new Board might well be empowered to undertake. Financially, once more, a reader of this report may well be led to wonder whether the industry, placed again in private ownership, will be able to finance soundly timed developments after about 1953 if there is no central financial body. Up to date the whole expansion of the industry has been financed from reserves. But in the future those reserves will be exhausted whilst profits ploughed back are likely hardly even to be sufficient for maintenance and replacement of capital assets. During the unscrambling of the financial omelette of nationalisation will the banks and the public feel sufficiently assured about the industry's future to lend money to individual firms?

Outside finance the relationship that has grown up between the Corporation and the Federation may in several respects prove the model upon which to build up a relationship between the new Board and the Federation. Furthermore, the new Board, if and when it takes up its duties, will certainly be interested in the thoughts and plans of the Corporation. The views are expressed in the report, for instance, that certain companies which have hitherto been operating separately might with advantage be more closely associated ("some steps in this direction" have been promoted); that "there is scope for the integration of the working" of certain companies engaged in ore digging; and that the safeguarding of imported ore supplies "may require increased participation in the ownership and control of suitable foreign ore fields." Those views, the detailed arguments, not mentioned in the report, which support them, and any actions taken are certain to be of interest to any new body that becomes responsible for the future of the industry. Last but not least, the work the Corporation has been doing in conjunction with the Federation to plan the development and the timing of the development of the industry must prove of lasting value whether or not it is superseded by a Board with different powers.

PUBLIC POWER DEVELOPMENT IN AMERICA

The fact that virtually all the free world hailed with satisfaction the nomination of General Eisenhower to be the Republican candidate for the Presidency of the United States is not surprising. He is admired by all with whom he has come into contact, and he has inspired a high degree of confidence. To still others he stands as a symbol of American co-operation, friendship and leadership. His nomination is regarded as an assurance that there will be no change in the basically helpful attitude toward the N.A.T.O. countries, which is one of the fundamentals of current American foreign policy. However, it is unfortunate that the Republican convention did not formulate its stand on certain domestic issues in as clear a manner as it did on matters of collective security and the defence of the free world. The weakest phase in the Republican position at the moment is the party platform, just as the presidential candidate chosen is its strongest phase. On certain points issues were not bravely spelled out by the Republicans in Chicago. On their side, the Democrats received an opportunity to be more explicit in the field of civil rights. But through their selection of Mr. Stevenson as presidential candidate it is left doubtful whether they wish to go further than the Republicans in the direction of national health insurance, the public development of water power and the safeguarding of the public lands. Engineers are particularly interested in the parties' stand on federal reclamation and hydro-electric power generating schemes, and this

point may become a controversial one in the approaching election campaign, especially in the Western States.

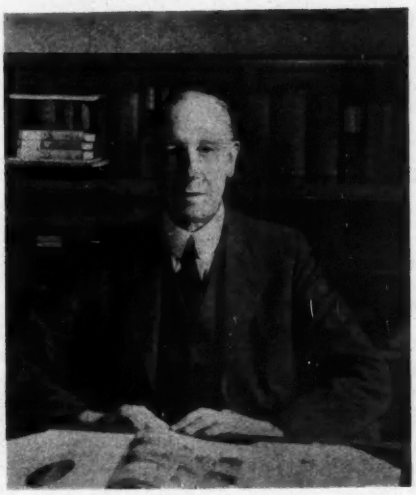
Mr. Truman's attitude towards federal reclamation and power generation, with which Mr. Stevenson's may, or may not, correspond, found expression in his speech delivered at the dedication of the Bull Shoals and Norfolk dams on the White River in Arkansas on July 2nd. These multiple-purpose structures were built by the U.S. Army Corps of Engineers and have a total storage capacity of 5,408,000 acre-feet and 1,983,000 acre-feet, and an ultimate generating capacity of 320MW and 140MW respectively. While the flood control aspect of the scheme was approved universally, local electric power companies put up a long and bitter fight against the construction of these two dams on the grounds that the resulting hydro-electric generating facilities would constitute an unfair federal competition. Mr. Truman thus had an opportunity at the dedication of the dams to lash out at America's private power companies for opposing the federal development of hydro-electric projects. The President gave the impression that the power companies have contributed little, if anything, to the public good ; " Sooner or later the private power companies are going to find out that they cannot stand in the way of what the people need in this country. And the sooner they find it out the better it will be for everybody concerned." Nowhere in the Bull Shoals speech was there a conciliatory tone toward the power industry. Nowhere was there an offer of co-operation. Yet the President's Materials Policy Commission in a statement issued just a few days previous to the speech made this recommendation : " To enable private utilities to expand and advance technology, it is obviously important that all related government policies—federal, state and local—should be shaped to provide conditions favourable to intensive technological research and development and to capital expansion, balanced with full protection of the consuming and investing public." The Materials Policy Commission says the federal government will have to continue to develop hydro-electric sites where multi-purpose development of a river basin represents the best approach, but it adds : " There will be cases where part or all the job can be handled by private business, particularly where a site can be developed best on a single-purpose basis, or where private industry and government can collaborate in a multi-purpose development."

Here, then, are two statements, both coming out of the White House, but presenting an interesting contrast in tone. Judging by recent speeches, one may expect General Eisenhower and Senator Nixon, the vice-presidential Republican candidate, to subscribe to the policy expressed by the Materials Policy Commission. On the Democratic side, Senator Kefauver positively favoured comprehensive federal multi-purpose development of water-power resources. The same could be said for Senator Russell, who was a co-sponsor of the T.V.A. Act, and who has been instrumental in obtaining federal funds for hydro-electric projects in his State of Georgia. Senator Kerr and Averell Harriman were both known to be ardent "Fair Dealers" and to advocate river development on an authority basis. But Governor Stevenson of Illinois is probably less federal-power-minded than any of these men and he has openly declared that in his opinion government should not compete with private business in matters of electric power. However, now that he has been nominated, he is expected to support the present extent of public power generation plans. It may thus be noted that, thanks to the defeat of Senator Taft and the Republican " old guard," there is now not too great a cleavage between the two parties on these matters, and it is reasonably certain that, no matter what happens at the ballot boxes in November, construction of such schemes as the T.V.A., the Columbia Basin and the Central Valley projects will continue.

Obituary

CHARLES BENJAMIN COLLETT, O.B.E.

RAILWAY engineers throughout the world will hear with sincere regret of the death of Mr. Charles Benjamin Collett, on Saturday last, August 23rd, at the age of eighty-one years. Mr. Collett was for many years pre-eminent as a British locomotive designer, and when he succeeded the late Mr. C. J. Churchward as chief mechanical engineer of the Great Western Railway Company in 1922, after serving as assistant chief mechanical engineer for three years, he carried on a great tradition. During the nineteen years he held the post of chief mechanical engineer till his retirement in 1941 he added to, and improved on, much of what had gone before, and was responsible for the design of some of the outstanding locomotives of the day.



Charles Benjamin Collett

Mr. Collett was born in 1871 and after receiving his preliminary education at the Merchant Taylors School he went to the City and Guilds Engineering College at South Kensington. He afterwards served as a pupil to Mr. Joshua Field of that famous firm of marine engineers, Maudslay, Sons and Field, and in 1893 entered the service of the Great Western Railway Company as a draughtsman at the Swindon works. Within a short period Mr. Collett's outstanding ability led to his promotion and in 1898 he was appointed assistant to the chief draughtsman at Swindon. Two years later he became a technical inspector in the Swindon works, and in the same year, 1900, was appointed assistant works manager. In 1912 he became works manager and seven years later, in May, 1919, was made assistant chief mechanical engineer.

During the years that Mr. Collett held office as chief mechanical engineer a great change took place in the design of locomotives on British railways, and during that time Swindon exerted a great influence on British locomotive practice. In his " Castle " class of locomotives, which he introduced in 1923, Mr. Collett was responsible for designing one of the outstanding locomotives of all time, and this class was followed by the no less important " King " class of 1927. When they were introduced, the locomotives of the four-cylinder " Castle " class with a tractive effort of 31,626 lb, developed a greater drawbar pull than any other British engine, and by its excellent design the engine was recognised to be ahead of any other locomotive of its time. The " King " class was a natural development from the " Castles," and those four-cylinder engines, which incorporated the best points in preceding G.W.R. locomotives, had a tractive effort of 40,300 lb.

Soon after his appointment as chief mechanical engineer, Mr. Collett saw the desirability of maintaining a minimum number of standard types of engines to suit the traffic requirements of the G.W.R., and he inaugurated an extensive programme of locomotive standardisation. In 1921 the company's stock included seventeen types comprising fifty-two classes of engines, but as a result of the work of standardisation there were, by 1941, thirteen types and thirty-seven classes. This large reduction in the number of types, with the corresponding increase in the number of interchangeable parts, both greatly reduced running costs and expedited overhauls. One of the important parts of this work of standardisation was Mr. Collett's insistence upon absolute accuracy in boiler dimensions in the course of construction in order that standard boilers should be interchangeable.

He also took a particular interest in carriage and wagon design and was responsible for notable improvements in restaurant cars, sleeping cars, special train sets, and saloon coaches. A new profile developed by him for G.W. stock in 1937 enabled the stock to be used for cross-country working on other companies' lines.

Mr. Collett played an important part in connection with the equipping of Great Western locomotives with automatic train control, and he was a member of the second special committee set up by the Ministry of Transport in 1927, under the chairmanship of Sir John Pringle, to consider the introduction of a standard system of automatic train control for the whole country. The committee considered numerous devices, many of which were in use in different parts of the world, and unanimously came to the conclusion that the system used on the Great Western Railway was the most satisfactory for adoption by British railways.

Throughout his career Mr. Collett showed a great interest in the conditions of work and the problems of the men under him, and he was much respected for his consideration and helpfulness by all with whom he came into contact. As a result of his work during the 1914–18 war Mr. Collett was awarded the O.B.E. He was a member of the Institution of Mechanical Engineers from 1920 till 1941 and a member of the Institution of Civil Engineers from 1922 till 1941, when he retired from railway service.

With the death of Mr. Collett the profession has lost a quiet, kindly man of out-

standing ability, whose name will always stand high in the annals of locomotive history and British railways.

SIR JOHN FORBES WATSON

IT is with regret that we have to record the sudden death of Sir John Forbes Watson, K.C.M.G., at his home in London, on Monday, August 25th. Sir John, who was seventy-two, had been the director of the British Employers' Confederation since 1921, and his distinguished work for the Confederation did much to establish the status it enjoys to-day.

John Ballingall Forbes Watson was born on October 10, 1879 ,at Milnathort, Kinrossshire. He was educated at Dollar Academy and at the University of Edinburgh, where he was president of the Union, and at the Universities of Paris, Gottingen and Heidelberg. He was called to the Scottish Bar before the 1914–18 war, but from 1915–19 Sir John served in the R.F.C. and the R.A.F. He was then called to the English Bar by the Middle Temple. About this time also he was the secretary of the National Light Castings Ironfounders' Association, later becoming secretary to the body now known as the British Employers' Confederation, of which he shortly afterwards became director. During his many years in this office he was brought into contact with most leading industrialists, Government Departments, and trade unionists, and he served on several Government committees. He was a member of the British Employers' delegations to the annual conferences of the International Labour Conferences from 1922 onwards ; at several he was the chief delegate, and from 1941/47 he was vice-president. He held a number of distinguished positions in the International Labour Office itself since 1928, and represented that organisation at the World Economic Conference in 1933 and at San Francisco in 1945. He had served on the executive committee of the International Organisation of Employers since 1922, and had been chairman of that committee since 1949. In 1932/33 he was president of the organisation.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

PRESENT-DAY LOCOMOTIVE WORKING IN GREAT BRITAIN

SIR,—Referring to Mr. Poultney's letter published in your issue of July 11th, it is interesting to note that in spite of all shortcomings the orthodox locomotive valve gears and distribution systems have not been superseded by any of the various types of poppet gears which have been introduced from time to time. They make their appearance with a flourish of trumpets and then quietly fade away.

In the early 'twenties the L.N.E.R. (G.E. Section) fitted the " Lentz " poppet valve gear to a number of 4-6-0 engines. In due course the engines were withdrawn from service to be fitted with the standard Stephenson link motion and piston valves common to the class. Some report on the results obtained may have been published, but the writer cannot recall any information in the technical Press.

The same railway experimented with graphite lubrication for valves and cylinders, with feed heating on the " Weir " system incorporating a tubular heat exchanger and on the direct-contact system (the AGFI ?) with two heating chambers between the chimney and the dome. These innovations duly passed away with never a published report, to the writer's knowledge.

Possibly the Railway Executive will be less secretive and its " open secret " trials of a poppet valve gear may eventually be described in a report intended for publication.

Turning to the review of " Locomotives and Their Working " (*vide* the issue of July 18th), it is not clear why your reviewer regards as a " time-honoured misconception " the statement that " The smaller the wheel the better the rate of acceleration." The smaller the wheel the greater the number of revolutions in a given time and the greater the power developed—all other factors being unchanged. Putting it in another way, the smaller the wheel the lower the gear ratio and the higher the rate of acceleration. A few minutes experimenting with a three-speed bicycle will afford convincing proof, apart from the well-known acceleration characteristics of automobiles.

When the remarkable Liverpool Street/Enfield accelerated service was introduced 0-6-0 tank engines, with small wheels, were utilised to give the rapid acceleration characteristics required. In his daily journeyings, the writer travels in a train which frequently departs simultaneously with a second train of similar stock and weight. This train is hauled by a G.W. 2-6-2 tank and the writer's train hauled by a 4-4-0 Midland compound invariably falls behind as the two trains accelerate.

At one time it was held that small wheels were desirable from the viewpoint of acceleration, but were unsuitable for high speeds. It is the latter part of this statement which may be regarded as a time-honoured misconception.

Wirral, Cheshire, E. B. PARKER
August 23rd.

THE FUTURE DEMAND FOR COAL

SIR,—I have seen Mr. Gamlen's letter in your issue of July 25th, and Mr. Fox's reply of August 8th, and should like to make a few observations. The comparative figures for the efficiencies of electric and gas space heating originally quoted by Sir John Hacking and referred to by Mr. Gamlen will not bear examination by any truly impartial critic. If it is true that on average 2 tons of coal produce 150 therms of gas and 1 ton of coke, no amount of juggling with costs can alter the fact that we should need to burn at least 1½ tons of coal at 19 per cent efficiency to give the same heating power as 150 therms of gas at 50 per cent efficiency. In other words, the use of gas for space heating gives a fuel saving of 25 per cent over electricity or the open grate. These figures may be challenged in detail, but the broad conclusion is the same.

On the subject of back-pressure power generation it is remarkable that those with little experience of this method of working seem always to imagine that there are enormous difficulties either in practical operation or in making an economic success of it, unless there is a " perfect balance " between heat and power requirements. I am glad to see that in his latest letter Mr. Gamlen has corrected his earlier statement to this effect, and Mr. Fox has rightly pointed out that there are many thousands of combined heat and power plants all over the world, in which perfect balance is the exception rather than the rule. I myself have had intimate experience of several, and in one of these we could only generate about one-third of our total power load in the summer months, and yet not only were there no operating difficulties, but we made a handsome profit. I know of other cases where the back-pressure plant is shut down altogether in the summer and is still found to be an economic proposition.

In the past the classic solution of the out-of-balance problem used to be the pass-out turbine, assisted by such schemes as steam refrigeration mentioned by Mr. Fox. Now that the British Electricity Authority has somewhat reluctantly accepted the principle of parallel running, there is no longer any real case for the pass-out condensing machine. Whatever the state of the steam power balance, the back-pressure machine generates all the power it can ; any power deficiency is imported from the grid and any surplus is exported to the grid. The controls are delightfully simple and the fuel saving is enormous.

In his earlier letter Mr. Gamlen inquired why, if back-pressure plants were so good, there were not more of them. There is a very simple answer to this. Until comparatively recently the electricity supply industry used every means in its power to discourage the private generation of electricity in this country. Sometimes excessive standby charges were quoted if any additional power had to be purchased ; on other occasions there was a definite prohibition against parallel running, or yet again power was offered at specially attractive rates to any firm contemplating the installation of private plant. This attitude unfortunately still persists in some areas, but it is quite wrong from a national fuel policy standpoint.

H. M. PEACOCK
B.Sc. (Eng.), M.I.Mech.E., M.Inst.F.
London, August 17th.

SIR,—I have noted the remarks made by Mr. Gamlen in his letter which was published in your August 15th issue, but it would seem that a discussion of the economics of the carbonising industries is irrelevant to the main theme of the correspondence on this subject. Scientific and engineering developments in the gas and coke industries are covered quite adequately in the technical Press from time to time. The thermal efficiency of a modern gasworks is about 73 per cent, and, as in the case of the electricity supply industry, a significant improvement on this value may be expected during the coming years. To what extent new construction incorporates the latest technical advances arising from research is not for me to say.

In general, the rate of increase in the demand for coal by the two carbonising industries is determined by the rapidity with which both new gasworks and coke ovens can be commissioned. At the present time variations in the demand for gas are not the determining factor in the matter of coal consumption. Although there is now a general slight downward trend in electricity consumption, the South-Eastern Electricity Board actually showed an increase of 2·1 per cent for June, 1952, as compared with June, 1951. I have never yet heard of anybody in its area rejoicing about low charges. Would that they could !

Mr. Gamlen refers to by-products, and I would only say that some interesting particulars may be found in the booklet *Treasure in Coal*, a publication recently issued by the Gas Council.

JOHN FOX
M.I.Mech.E., Associate I.E.E., F.Inst.F.
Hove, August 16th.

TECHNOLOGIST AND TECHNICIAN

SIR,—It would help me—and, I suspect, many of your readers—if you define and explain just what is meant by a technologist and a technician. To judge by Sir John Hacking's remarks to the B.T.H. Summer School reported in your issue of August 15th, a technologist is not an engineer, not yet a graduate—or he would have been so called. If one understood these terms, one could follow better the discussion on the value of universities relative to institutes of technology. Perhaps you could elucidate the matter.

J. M. KIRKBY,
Alverstoke, Hants, M.A., A.M.I.Mech.E.
August 15th.

[According to a memorandum prepared by the Education and Training Committee of the Institution of Electrical Engineers, a professional electrical engineer (presumably a technologist) " is one who is competent through his education

and training to assume personal responsibility for developments in electrical engineering; to apply the scientific outlook and method to the initiation, organisation and supervision of technical work; to give authoritative technical advice, and to exchange ideas with his fellows for the general furtherance of science and its applications." An electrical technician is defined as "a person who carries out in a responsible manner approved techniques which are either common knowledge amongst those who are technically expert in his branch of industry or specially prescribed by professional electrical engineers. These techniques are not those of the craftsman, though they may involve manual skill; in many cases they include the skilled use of delicate and complicated instruments and may also require the intelligent and accurate use of approved methods of calculation. They involve practical experience of some limited branch of electrical engineering combined with the ability to complete the details of a project using well-established practice."—ED., THE E.]

THE GRESLEY "PACIFICS"

SIR,—In Mr. Nock's instructive article on page 78 of your issue of July 18th he says: "in laying down post-war standards . . . the L.N.E.R. . . . decided to employ not more than two cylinders in all engines of moderate power, and to fit the larger engines . . . with three separate sets of valve gear."

Surely this is giving too great prominence to the ideas of Edward Thompson, which did not prove binding upon his successor.

L. A. FULLAGAR

"Bradnor," Whetstone, N.20, August 16th.

Metallurgy in the Mechanical Spring Industry

A REPORT has been published of the 1951 William Park Woodside Lecture, bearing the above title, delivered by F. P. Zimmerli, before the Detroit Chapter of the American Society for Metals.[1] Consideration was limited to springs formed to any shape at room temperature, with or without subsequent heat-treatment, and made of any flat material ½in or less in thickness, or of rounds ½in diameter or less. In the first part of the lecture, information about the materials used for such springs is reviewed. The characteristics of steels used are described, including alloy steels, particularly chromium-vanadium steel, and higher alloy compositions for withstanding high temperatures. Steels are by far the most important spring materials; then come copper alloys and nickel alloys, which together amount to less than 5 per cent of the total. More space, however, is devoted to non-ferrous materials on account of their variety, and in some cases, their novelty. Among copper alloys, beryllium-copper is, in some respects, outstanding. It is the best conductor of electricity among materials of its hardness, its resistance to corrosion and corrosion fatigue is high, but it is attacked by sulphides and deteriorates rapidly when exposed to halides at slightly elevated temperatures. Hence, it cannot be used in contact with exhaust gases from high octane fuels which contain lead bromide. Nickel alloys afford even greater variety and their use is increasing in spite of the continued shortage of this strategic material. The successive development of K Monel, Inconel, Inconel X, &c., resulted in progressive improvement in properties at high temperatures. Elinvar, with constant modulus of elasticity at temperatures between −100 and +150 deg. Cent., its resistance to oxidation and corrosion, immunity from magnetic effects and low thermal expansion, becomes an ideal material for precision springs. Elgiloy (Elgin Watch Company) and Cobenium (W. B. Driver Company) are precipitation hardening cobalt-chromium-nickel alloys, corrosion resistant, non-magnetic and of a quality specially suitable for watch springs, though the lecturer speculates as to whether 17–7 PH stainless steel (chromium 17 per cent, nickel 7 per cent, aluminium 0·75 to 1·25 per cent, precipitation hardened) might not do as well in most circumstances. There is finally a brief reference to non-metallic spring materials such as glass or quartz filaments, the manufacture of which is, however, a specialised subject.

In the second part of the lecture, heat-treatment, setting and shot peening are dealt with. When oil-hardened or cold-drawn spring steel wire or strip is used, it becomes desirable to remove as much as possible of the residual stresses arising from the forming operation by heating to the maximum temperature that will not reduce the properties of the material below specified values. For most steels, this is 400 to 425 deg. Cent. For some music wire springs 190 deg. to 240 deg. Cent is employed, but not when the spring is to be exposed to temperatures above 100 deg. Cent., or when maximum endurance is desired. Such low stress-relieving treatment will, however, give somewhat greater resistance to static load conditions at room temperature. Many parts, like valve springs, benefit from the extra endurance conferred by shot peening. Heating to 230 deg. to 260 deg. Cent. after shot peening has been found satisfactory. Increase in fatigue range due to shot peening may be 50 or 60 per cent in steel and 100 per cent in phosphor bronze. Experimental results obtained with different size and hardness of shot are described. The effect of shot peening is attributed to the introduction of compressive stresses in the surface layer and to slight work-hardening action. Stresses put into the metal by mechanical means can, however, be removed by the same method. If, therefore, parts are stressed beyond the elastic limit, the internal compressive stresses can be removed, or will certainly be reduced, so that the fatigue life under tensile stress will be adversely affected. It follows also that in springs which work from a zero stress to high values in both directions (for example, a compression spring being used for both compression and tension) the high fatigue values expected from a shot peened spring will not materialise.

The concluding section of the lecture dealt with spring failures and their causes. Fatigue failures are the most frequent type, and in this connection the lecturer pointed out that for small wire sizes (⅛in or less), with equally good surface and other suitable characteristics, there is no difference in the endurance of alloy steel and carbon steel at room temperature. For infinite fatigue life a change in the kind of steel (for the sizes indicated) will be of little or no help though for short life (less than 100,000 stress applications) some variation in endurance from one steel to another may be expected. Among the principal causes of fatigue failure are surface and sub-surface cracks, and corrosion. Plating involves a risk. No plated spring has quite the endurance of the unplated spring under non-corrosive conditions of service. Cadmium is stated to be better than zinc in that it affects spring life less. Phosphate coatings do not leave the spring in as good a condition as before, desirable though they may be for other purposes. Decarburisation is an infrequent offender; and even when partial decarburisation is evident, it has not, in the lecturer's opinion, any serious effect, whilst improper heat-treatment has become a less common occurrence. Automatic time-temperature control as employed in modern heat-treating departments has almost completely eliminated this once common cause of breakage.

[1] *Metal Progress*, May, 1952, Page 97; June, 1952, page 97; July, 1952, page 84.

Literature

SHORT NOTICES

Marine Auxiliary Machinery. Edited by E. Molloy. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 35s.—To maintain the efficiency of a ship it is essential that the auxiliaries receive proper care and attention and this book contains comprehensive information on the subject of marine auxiliary machinery. The subject matter has been carefully arranged to give a clear picture of the various interconnected systems and the individual chapters have been contributed by experts who have special knowledge of particular problems. The first chapter deals in broad terms with the engine and boiler arrangements of a number of vessels and then pipes and valves are discussed, to be followed by chapters which fully review a number of pumping systems, first upon a theoretical basis and then from the point of view of practical application. Another section is concerned with a detailed consideration of the problems of pump installation and of maintenance and repair, while the next chapter has something to say about compressors, condensers, evaporators and purifiers. The second part of the book deals with auxiliaries not directly serving the main propulsion machinery; various steering gears and controls are examined and there are some general notes upon propellers. In the succeeding chapters fundamental data are given upon the important subjects of refrigeration, heating, ventilation and air conditioning, together with general information related to the various designs of deck machinery. A final chapter touches upon the main categories of safety equipment. The book forms one of the publishers' Marine Engineering Series, and is profusely illustrated with reproductions of photographs, line drawings, and graphs, which serve to increase the value of the text and help to make this book a useful work of reference for marine engineers.

Safety Rules for use in Chemical Works. Part II: Detailed Instructions. London: The Association of British Chemical Manufacturers, 166, Piccadilly, W.1. Price 25s.—This book completes a project begun in 1928 and takes account of the far-reaching advances in chemical technology and developments which have taken place since it was issued in provisional form in 1930. As indicated by the title, the book deals specifically with chemical works and sets out in detail the safety precautions required, how they should be arranged and where the necessary information can be found. There are eleven chapters, in which legislation is extensively reviewed, safety organisation is discussed, and all aspects of fire explosion and industrial poisoning problems are commented upon. A short chapter touching upon the effect of corrosive metals is followed by full notes concerning the cleaning of and entry into confined spaces, and permit-to-work certificates. The necessary medical and first aid services are generally surveyed and the whole field of working conditions is examined, while in the last chapter the subject of protective clothing and appliances is explored and British Standard Specifications quoted.

BOOKS RECEIVED

Wood. Vol. 8 of Selected Government Research Reports. London: Her Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 21s.

Introduction to the Theory of Mechanics. By K. E. Bullen. London: Cambridge University Press, Bentley House, 200, Euston Road, N.W.1. Price 21s.

Safe Working Loads of Lifting Tackle. Second edition. By L. Linder. London: Coubro and Scrutton, Ltd., 11, West India Dock Road, E.14. Price 42s.

Principles of the Control and Stability of Aircraft. By W. J. Duncan. London: Cambridge University Press, Bentley House, 200, Euston Road, N.W.1. Price 40s.

Introductory Soil Mechanics and Foundations. By George B. Sowers and George F. Sowers. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 32s.

Radio. Vol. I. By John D. Tucker and Donald F. Wilkinson. London: English Universities Press, Ltd., St. Paul's House, Warwick Square, E.C.4. Price 7s. 6d.

Fire Protection and Accident Prevention Year Book, 1952. Twelfth edition. Compiled by Geoffrey F. D. Pratt. London: Benn Brothers, Ltd., Fleet Street, E.C.4. Price 10s. 6d.

Reports on Progress in Physics. Vol XV (1952). Executive editor, A. C. Stickland. London: The Physical Society, 1, Lowther Gardens, Prince Consort Road, S.W.7. Price 50s.

Engineers' Approach to the Economics of Production. By John Reid Dick. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 21s.

Extrusion of Plastics, Rubber and Metals. By Herbert R. Simonds, Archie J. Weith and William Schack. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 80s.

Electricity Supply Developments in Southern Ireland

No. II—(*Concluded from page 254, August 22nd*)

As recorded briefly in our issue of July 4th last, members of the Institution of Electrical Engineers who attended the Institution's summer meeting in Dublin at the end of June were able to see a little of what has been done to develop electricity supply in Southern Ireland. In recent years peat-burning stations have been built to augment the supplies derived from water power, and the installed capacity of peat fired plant is now about one-third of the hydro-electric installed capacity. Some recent developments are briefly described herewith.

PEAT produced on Clonsast bog, as described in last week's article, is burned in the nearby Portarlington generating station, Co. Leix, which was commissioned in January, 1950. This station houses two 12·5MW turbo-alternator sets taking steam from three boiler units, each with a normal capacity of 125,000 lb of steam per hour, the whole installation being designed to use the entire output of machine-cut peat from Clonsast. The fuel store flanking the boiler-house measures about 250 yards by 50 yards, and has a capacity of about 40,000 tons.

The peat is in the form of sods measuring about 10in by 3in by 3in, having a moisture content of 30 per cent, a gross calorific value of 6200 B.Th.U. per pound, and an ash fusion point of 1100 deg. to 1150 deg. Cent. Preparatory to combustion on the chain grate stokers the peat is passed from the boiler-house bunkers into a retort where it is dried by preheated air. The boilers are Babcock and Wilcox units, each having a maximum continuous rating of 150,000 lb per hour and a peak (one hour) rating of 163,000 lb, the steam pressure being 425 lb per square inch and temperature 825 deg. Fah. The generators are A.S.E.A. radial-flow, 12·5MW turbo-alternator sets, running at 3000 r.p.m., and generating their output at 10·5kV, 0·8 power factor.

Circulating water is dealt with by a single reinforced concrete hyperbolic cooling tower, which is 236ft high, 170ft internal base diameter, and is capable of handling 1,800,000 gallons of water per hour with a temperature range of 80 deg. to 70 deg. Fah. at 75 per cent relative humidity.

The station output is stepped up by two A.S.E.A. 20MVA generator transformers in the adjoining outdoor switching station and transmitted thence by 110kV overhead line to Portlaoighise. The normal annual output from Portarlington is in the neighbourhood of 90 million units.

Allenwood generating station was designed and built to use peat won from the adjoining bogs at Timahoe (Co. Kildare), part of which may be seen in the background of the accompanying aerial photograph of the station (Fig. 7). The peat has similar properties to that which is harvested at Clonsast and it is burned on chain grate stokers firing four Babcock and Wilcox boilers which have the same capacity and steam conditions as those at Portarlington. The generating plant consists of two G.E.C. axial-flow turbo-alternator sets, each rated at 20MW, 0·8 p.f. when running at 3000 r.p.m. Normally, generation is at 10·5kV, but each alternator is designed to give its rated output of 20MW at any voltage from 9·5kV to 11·5kV. Each alternator is also designed to generate 70 per cent of its rated kilovolt-amperes at zero power factor leading. Finally, because of local system conditions, the specification called for a short circuit ratio of 0·75 at normal voltage—which is higher than the usual value. Because of the unusual conditions—the considerable voltage regulation and the high short circuit ratio—the alternator air gap is larger than normal, and the dimensions of the machine are correspondingly larger. In other respects the sets are of orthodox design and construction.

There is a single reinforced concrete hyperbolic cooling tower, 286ft high, 205ft internal base diameter, which serves the whole station and handles 2,400,000 gallons of water per hour, with a temperature range of 82 deg. to 70 deg. Fah. at 75 per cent relative humidity.

Work on the construction of Allenwood generating station began in February, 1949, and the first generating set was commissioned in January last. The second set is expected to be in commercial operation before the end of this year. The estimated annual output of the station is 135 million units and provision has been made for the installation of a third set, if required, at a later date.

The generator voltage is stepped up by two 10/110kV, 20MVA, B.T.H. outdoor transformers. A view of the adjoining outdoor switching station with its air-blast circuit breakers is reproduced in Fig. 8. The station is linked by three-phase, 110kV, overhead lines with Portlaoighise and Inchicore.

As stated in the first part of this article, the importance of the Electricity Supply Board's fuel-burning stations is to be judged not by their size, but by the fact that they represent approximately 50 per cent of the Board's total generating capacity, and contribute 53 per cent of the total number of units generated. When the second set is commissioned at Allenwood the two peat-burning stations will have an installed capacity of 65MW. The coal and oil-burning stations have a combined capacity of 107MW, ignoring the old Cork station, the output from which is negligible.

Pigeon House (Dublin), the larger of the two stations in this category, is a coal-burning station which was originally built and operated by the Dublin Corporation in 1903 and was taken over by the Electricity Supply Board in 1929. At that time the largest generating set was one of 5MW and the total station capacity was 21MW. Between 1933 and 1940 the station was rebuilt and modernised and the total installation was increased to 95MW, which was made up of two Oerlikon 20MW sets, two Siemens-Schuckert 20MW sets, one A.E.G. 10MW set, and one Oerlikon 5MW set. Steam for these sets is generated at 265 lb per square inch and 770 deg. Fah. in eleven Babcock and Wilcox boilers equipped with chain grate stokers. The boilers have a normal evaporative rating of 100,000 lb per hour.

The North Wall station, Dublin, is much smaller than the one at Pigeon House, but extensions are in hand which will raise the installed capacity from 12MW to 44·5MW. Originally

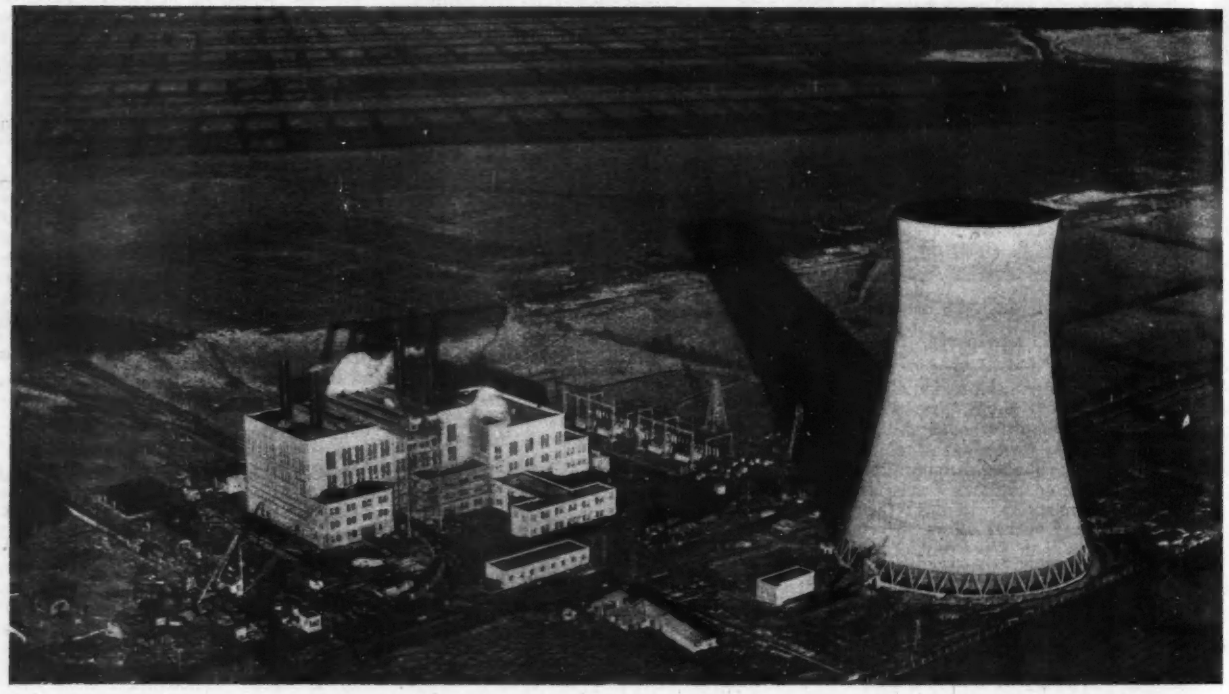


Fig. 7—Allenwood Peat Fired Generating Station, Co. Kildare

the boiler-house at North Wall was part of an oil refinery plant. When it was bought by the Electricity Supply Board in 1947 it contained four oil-fired boiler units, each with a rating of 40,000 lb per hour (425 lb per square inch, 800 deg. Fah.). The Board took steps to install a 12·5MW radial-flow A.S.E.A. steam turbo-alternator, and with this modest output the station was commissioned in 1949.

The additional generating plant which is the subject of the present extensions is interesting. It will consist of two Velox boilers made by S.A. Brown Boveri, with a maximum continuous rating of 166,000 lb per hour and steam conditions of 425 lb per square inch and 825 deg. Fah. The generating sets themselves will consist of two impulse reaction, 16MW, 3000 r.p.m., Brown-Boveri turbo-alternators.

At present the oil storage capacity of North Wall generating station is 9000 tons and the average annual output is 60 million units. When the extensions are completed the oil storage capacity will be increased to 25,000 tons and the average annual output in 1953 is expected to be about 180 million tons.

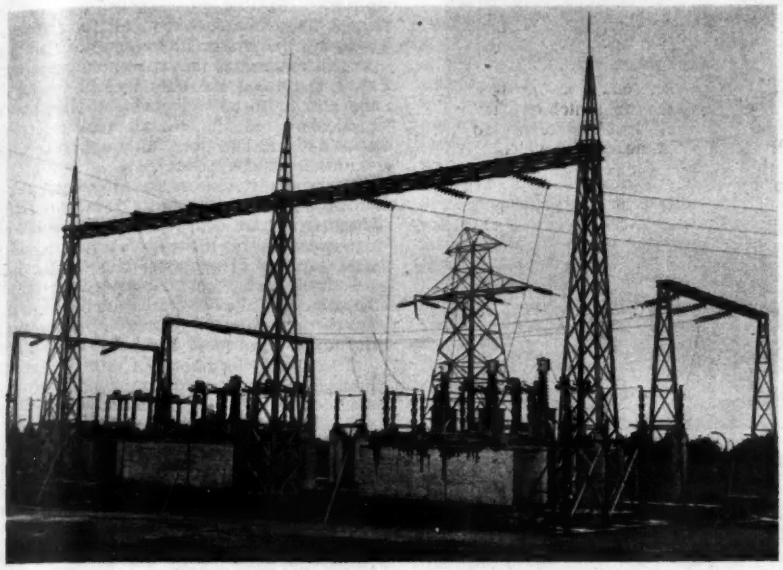


Fig. 8—Outdoor Switching Station at Allenwood

Hydro-Electric Developments

After the River Shannon system, with its 85MW generating station at Ardnacrusha, completed in 1934, the next major hydro-electric development was that of the River Liffey. Hydro-electric exploitation of the Liffey was started in 1937 and the final stage of the scheme was finished in 1949. The system utilises the waters of the River Liffey between Pollaphuca, some 15 miles to the south-west of Dublin, and Leixlip, some 12 miles to the west of the city. This stretch of the river includes the wide sweep which skirts the western slopes of the Dublin mountains before turning east towards the city and the sea.

The Liffey development consists of three generating stations : the first, of 30MW, is at Pollaphuca ; the next, of 4000kW, is at Golden Falls, about a mile down stream from Pollaphuca ; and the third, of 4000kW, is at Leixlip. From these three stations a total average annual output of about 41 million units is obtained, compared with the average annual output of about 310 million units from Ardnacrusha (Shannon). The importance of the Liffey stations lies not so much in their size as in their proximity to the Dublin load centre and in their contribution towards satisfying the peak demand.

At Pollaphuca a reservoir of about 5600 acres is formed by a mass concrete gravity dam which impounds the Liffey to a level of about 615ft O.D. From the dam a 16ft diameter tunnel, 1230ft long, carries water to Pollaphuca power station, where the generating plant consists of two English Electric 15MW turbo-alternators, the prime movers being Kaplan turbines, running at 300 r.p.m. under a gross head of 154ft. The two sets were commissioned in 1944 and 1947 respectively.

The output from Pollaphuca is stepped up by two A.S.E.A. 20MVA transformers to 110kV for transmission from the switching station by overhead lines to Inchicore and Waterford. Views of the power station and the adjoining switching compound are reproduced in Figs. 9 and 10. The high-tension switchgear is A.S.E.A. low-oil-content equipment.

From Pollaphuca the water discharges into a reservoir formed by a gravity dam at Golden Falls, about a mile downstream. A 10ft diameter penstock, 70ft long, carries the water to the English Electric 4MW set in the power station. The set consists of a vertical shaft propeller turbine running at 187·5 r.p.m. under a gross head of 57ft and coupled to a 5MVA alternator generating at 10·5kV. This set was commissioned in 1943. Power for the auxiliaries and local demands at Pollaphuca and Golden Falls is supplied by a 250kW horizontal set, embodying a Francis turbine, installed at Golden Falls.

Golden Falls is normally unattended and is under remote control from Pollaphuca through a 50V direct-current step-by-step system which operates latched-in relays. The two stations are operated in tandem, Pollaphuca taking the peak load and Golden Falls being run at full output for varying periods up to sixteen hours a day.

At Leixlip, the third of the group of stations, the Liffey is impounded to a level of about 149ft O.D. by a mass concrete gravity dam which forms a reservoir of about 100 acres. The generating set consists of an Escher Wyss 5800 h.p. Kaplan turbine coupled to a Brown-Boveri 5MVA alternator which generates at 10·5kV at 300 r.p.m.

To allow for the annual migration of salmon up the River Liffey a fish pass was incorporated in the dam, as described in our issue of April 1, 1949, p. 354. Some of the main particulars of the dams at Pollaphuca, Golden Falls and Leixlip are given in the accompanying table.

Principal Technical Particulars of Dams in River Liffey Hydro-Electric Development

Particulars*	Pollaphuca	Golden Falls	Leixlip
Catchment area, km² ...	312	312	854
Average annual flow, m³/sec	9·5	9·5	14·7
Storage capacity, 10⁶m³ ...	150	0·£	0·75
Average head, m	46·9 (154ft)	17·4 (57ft)	17·5 (57·5ft)
Dam : Length, ft	256	320	374
Height, ft ...	104	50	80
Spillway gates, number and width	Three, 23ft	Three, 23ft	Three, 20ft

* 1 cubic metre=35·315 cubic feet, 1 acre-foot=1233·47 cubic metres=43,560 cubic feet.

The most recent of the current hydro-electric developments in Southern Ireland are those on the River Erne, which rises in Lough Gowna, on the west coast. Work was begun in 1946 on the scheme, which comprises two power stations on the stretch of the river lying between Belleek and the sea at Ballyshannon. Some of the main technical particulars are tabulated herewith :

Principal Technical Particulars of Erne Hydro-Electric Development

Catchment area	3950km² (1524 square miles)	
Average annual rainfall	1050mm (41·4in)	
Average annual flow ...	102·1m³/sec (3600 cusecs)	
Storage capacity	194×10⁶m³ (6 per cent of annual flow)	
	Cliff	Cathaleen's Fall
Dam length	690ft	844ft
Dam height	60ft	90ft
Sluice gates, number and width... ...	Three, 20ft ...	Three, 36ft

For the first station a dam is built across the river at Cliff to impound the water up to the existing level of the lower Lough Erne—that is,

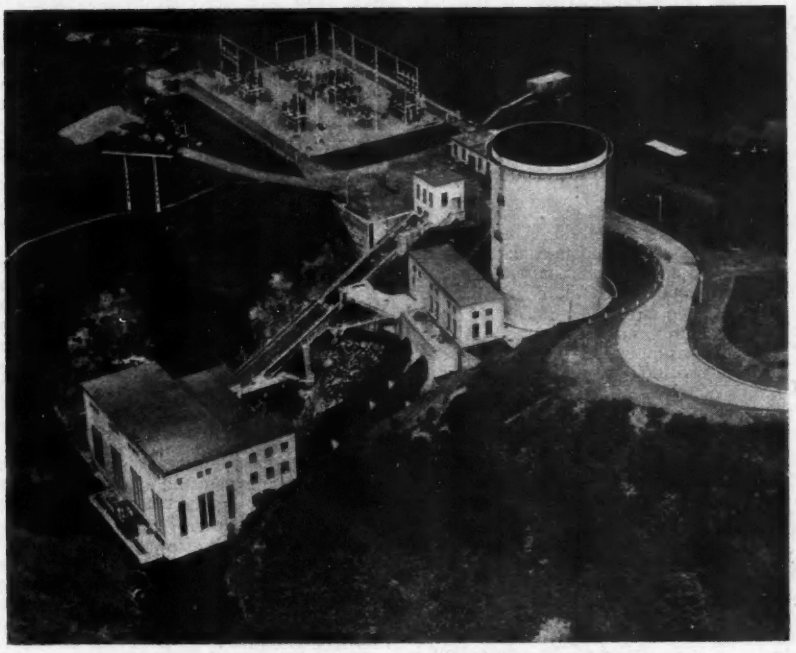


Fig. 9—Pollaphuca Hydro-electric Station

152ft. When Cliff station is complete it will house two generating sets. The first set, commissioned in 1950, is a Charmilles 14,250 h.p. Kaplan turbine, operating under a 10m head and coupled to a Brown-Boveri 12·5MVA alternator generating at 10·5kV when running at 115·3 r.p.m. The second set, which will be similar to the first, is expected to be commissioned in 1954. Power

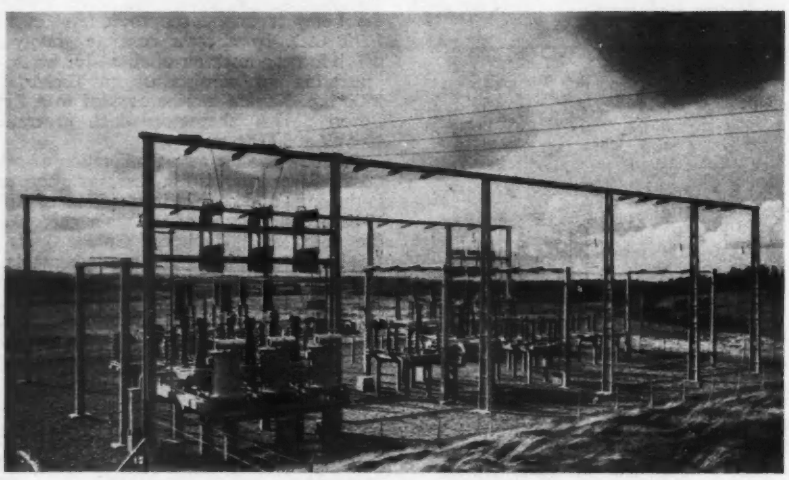


Fig. 10—110kV Switching Station at Pollaphuca

for auxiliaries and local supplies is provided by a 400kW set driven by a Francis turbine.

At the second station, Cathaleen's Fall, above Ballyshannon, the rest of the 152ft head is utilised by two K.M.W. Kaplan turbines, each coupled to an A.S.E.A. 30MVA alternator, which generates at 10·5kV at 187·5 r.p.m. The station is designed to accommodate a third generating set at a later date. Power for the station auxiliaries is supplied by a 400kW Francis turbine set. The first of the two 30MVA sets was commissioned in November, 1951, and the second in April, 1952. It is estimated that the output will be 215 million units per annum from the two power stations when the River Erne development has been completed.

FINGLAS TRANSFORMER AND SWITCHING STATION

Expansion of the country's generating capacity has been accompanied by extensions to the high-tension network and switching stations. Such developments apply particularly to the Dublin area, where it was clear shortly after the war that a second 110kV transformer and switching station would be required to supplement the existing station at Inchicore. Work was begun at the end of 1948 on a 13-acre site near Finglas, Co. Dublin; the switching station was completed in the summer of 1951, the first of two 30MVA transformers was commissioned before the end of the year, and the second transformer was commissioned recently.

A number of circuits are concentrated at and controlled from Finglas station. On the 110kV side there are two overhead lines to Drogheda, one to Erne and one to Inchicore, with provision for two more circuits in the future. On the 38kV side there are two circuits to Ballymun, one to Glasnevin, one to Grange, and one to Swords. The low-tension supply for the station itself is derived from two 100kVA outdoor transformers with a ratio of 38kV/380–200V.

The two h.t. transformers were made by Metropolitan-Vickers Electrical Company, Ltd., and link the 38kV and 110kV networks. The transformers are 30MVA units with a ratio of 110/38/10kV, connected star/star/delta tertiary. They have an on-load tapping range of 27·8kV to 48·5kV in twenty steps. The oil content is 7895 gallons and cooling is by built-on radiators, with twelve 0·6 h.p. cooling fans whose operation is automatically controlled by winding temperature.

Both the 110kV (outdoor) and the 38kV (indoor) sides of the station are designed as double busbar installations with bus couplers. All the circuit breakers are Brown-Boveri air-blast equipments. The 110kV breakers have a rupturing capacity of 2000MVA and the design is characterised by the omission of the usual air break switch in series with the arcing contacts. In the "off" position the arcing contacts are held open by compressed air. No mechanical coupling is provided between the three phases of the circuit breaker. The switchgear is mounted on reinforced concrete pedestals and lightning rods are fitted on all terminal masts to give protection from direct lightning strokes. The 110kV disconnects are arranged in line and all disconnects are fully interlocked to prevent incorrect local or remote operation. The 38kV circuit breakers are indoor units with a rupturing capacity of 1200MVA.

All the control, protection, metering, signalling and alarm circuits for the operation of the station are concentrated in the control room. A mimic diagram on the control panel, which is arranged along the walls of the room, represents the h.t. circuits and incorporates control switches with built-in signal lamps. Faults on any of the high-tension circuits or equipment are indicated visibly and audibly, and can be readily identified on a signal alarm tableaux which forms part of the operator's desk. Synchronising facilities are also provided in the control room.

Possibilities of Development in the Production of Iron*

By PROFESSOR ROBERT DURRER†

THE world is to-day producing iron at the rate of more than 200 million tons per year, for the most part as steel (in round figures 200 million tons) and a small part as pig iron (about 20 million tons). Almost nine-tenths of the total pig iron produced (some 150 million tons) is only an intermediate product, since it is converted into steel. More than half of the steel produced is obtained in this way, i.e. from pig iron, less than half from scrap. This ratio is slowly shifting in favour of scrap. Since some, although much less, scrap is also used in pig iron production, nearly half of the iron production, taken in its entirety, is derived from scrap and the other half from iron ore. The annual requirements of iron ore amount to some 250 million tons, which take over 100 million tons of coke to smelt.

Given these stupendous figures, iron production is proving more and more to be a problem of raw materials, just as indeed our whole life becomes more than ever dependent on materials found in the earth's crust. Resources that were abundant only a few decades ago are nearing exhaustion, and in the very near future the consumption of materials at the present rate will lead to a shifting of industries and to radical changes in our production methods. So far as concerns iron, this transformation has already begun, although on very modest lines; it will assume substantial shape before long.

In the broadest sense, man's task is to make the most rational use of the available raw materials, and to do so with an eye not only to the present but to the future; for the unsystematic exploitation of resources is a crime against posterity. The problem for steel makers is to transform production methods so as to make the best possible use of the raw materials at their disposal.

So far as the fuel required for heating and reducing the charge in iron production is concerned, this means that coke need no longer be, as it is to-day, the only fuel normally used; the aim must be to be able to use any fuel, particularly as the overall fuel reserves are also not inexhaustible, although much larger than those of coking coal.

With regard to ferrous raw materials, iron production methods must be adapted to the characteristics of the raw materials. Since about one-twentieth of the earth's crust consists of iron, supplies of our most important metal are practically unlimited. However, the lower the Fe content of the ores to be smelted, the greater are the impurities they contain, making the production process more and more difficult.

There is no likelihood of any change, in the immediate future, in the principle of iron production, i.e. reduction of the iron oxides. Thermal dissociation is out of the question and electrolysis cannot be considered for mass-production purposes. The principal means of reduction will remain, as in the past, carbon in some form of fuel, although it may be supplemented to some extent by hydrogen here and there, especially in areas which are poor in coal and rich in natural gas.

Almost all ore delivered for smelting at the present time is first reduced to pig iron, which is converted into steel by further refining. In contrast to this "indirect" process, efforts have been made for a long time to find a "direct" process, as existed in the days of the catalan furnace. These efforts are frequently made in the mistaken belief that production through pig iron is a roundabout method. But even the direct methods only yield an intermediate product which, although it has less impurities than pig iron, must, nevertheless, undergo a further process before becoming usable. This difference in the intermediate product is not the deciding factor; the vital point is which process is ultimately the cheaper. In the case of mass-production, the answer is the indirect method, which is more direct than the so-called "direct method" from the economic point of view. This fact does not, of course, preclude the possibility that a really direct steel production process may yet be discovered that is also economically more direct, but it is rather unlikely.

Almost all ore is smelted to-day in blast-furnaces, and almost all the liquid pig iron thus produced is converted into molten steel. So far as can be judged at the moment, this method of production, passing through an intermediate product, will continue in the future except that the intermediate product, so long as it is not used in foundries, will be far superior in composition to the pig iron of to-day. Accordingly, the subsequent refining process will have to be more flexible. Both processes, smelting and refining, will, nevertheless, be radically altered.

The fundamental defect in blast-furnace smelting is the use of atmospheric air, since it leads to the production of vast quantities of gas, which draw off equally vast amounts of heat from the hearth in the direction of the top of the furnace. In order that this heat can be substantially transferred from the rising gas to the descending charge, very high furnaces are required, up to almost 30m high. Moreover, this height is required to make indirect reduction (i.e. reduction with oxide of carbon) as thorough as possible, and thereby to lower coke consumption.

The less the specific quantity of gas, the less high need the furnace be, as electric smelting has shown in practice. The experience with the electric blast-furnace, modelled on the coke

*Extract from a report entitled "Recent Developments and Trends in Iron and Steel Technology," of the United Nations Economic Commission for Europe, Geneva.

†Director, Louis de Roll Iron and Steel Works, Switzerland.

blast-furnace, that reduction takes place only at the bottom of the shaft, led to the introduction of the electric low-shaft furnace, which consists of no more than a hearth. Although, other things being equal, a lower furnace is also cheaper, its greatest advantage is that it widens the limits of the raw materials that can be used. At one end of the scale is the blast-furnace with its high shaft, i.e. the furnace with a very high charge ; at the other, the low-charge furnace.

If we are to make the fullest possible use of available raw materials we must go over from the high-charge to the low-charge process. The electric low-shaft furnace is a practical example ; but there are limits to its uses because it operates on hydro-electric power, so that it can only replace the blast-furnace to a minor extent.

The specific quantity of gas can be reduced although to a lesser extent than by the suppression of the blast (as in electric smelting) by the complete or partial elimination of nitrogen, and the shaft can be shortened at the same time. In this direction may lie the best prospects of development for the smelting of ferrous minerals with the help of any kind of solid fuel. Blast furnaces are quite unsuitable for the reduction of ores with oxygen ; the enrichment of the blast with oxygen has a favourable influence on production and coke consumption only as long as the temperature of the furnace gas remains well above 100 deg. Cent. These advantages themselves are relatively small. The main advantage of reduction with oxygen cannot be achieved in blast-furnaces, but only in low-shaft furnaces. This need not prevent the small advantages to be gained by the use of oxygen in existing blast furnaces which, it may be added, are similar to those achieved by increasing the pressure of the blast. The fundamental defects of blast-furnaces can only be mitigated, not removed. Of course, since existing blast-furnaces will have to be used, they will remain for many years to come the foremost smelting apparatus. The process for reduction with oxygen in low-shaft furnaces, which has been proved in principle, should, however, be worked out without delay, so that it may be adopted wherever new iron and steel plants are erected or circumstances are otherwise suitable.

The metallurgical advantages of the oxygen low-shaft furnace apply not only to the production of iron, but also to other metals and alloys, particularly those with a high point of fusion. The ferro-alloys which cannot be produced in blast-furnaces should only be produced in oxygen low-shaft furnaces, as soon as the process has been developed in practice, and when coal is cheaper than electricity per calorie.

The charge is even lower in the low-shaft furnace when it is spread over in thin layers in the bath. Reaction conditions are ideal : fine ore is reduced by an admixture of fuel or by the carbon in the bath or both. Heating takes place via the bath, e.g. by oxygen blast, the burnt carbon being replaced by charging more fuel. The idea is old, but it has never yet been put into practice. If the difficulties in the way, which are practical rather than fundamental, could be overcome, iron ores and coal fines could be used direct in iron production.

An equally low charge is used for smelting in the rotary furnace, in which, as distinct from the shaft furnace, the material to be reduced is heated from the outside, while reduction takes place inside, as in the shaft furnace. The heating from outside is much less effective since it is slower and entails much loss as well as being very severe on the refractory-brick lining ; the heating is most efficient where the heat is produced within the material to be heated, as in the case of the shaft furnace. Smelting in the rotary furnace is already being practised in various forms. It has the advantage that it enables fine ores to be used ; its possibilities of application, at present still limited, depend upon local conditions.

Direct processes for steel production have already yielded excellent results, given suitable local conditions, if not for mass-production, at any rate for the production of special kinds of iron. This is particularly true of the processes developed and employed in Sweden for the production of sponge iron. In that country, with its magnificent resources in raw materials for iron production, the shortage of charcoal, which is the best fuel and reducing agent, is becoming more and more acute and its price has reached an exceptionally high level. It is therefore becoming increasingly expensive to produce the world-famous Swedish charcoal pig iron. Sponge iron can be used as a metallurgical substitute for charcoal pig iron in steel production, and if it can be produced cheaply enough its use is economically justified. It is a steel-like intermediate metal of extraordinary purity, when produced from pure or purified raw materials. Sponge iron is therefore, first and foremost, a high-grade scrap which can be substituted for unreliable commercial scrap in the making of steel, when certain metallurgical qualities are required or when it is economically feasible. It is now being more widely used wherever its use can lower production costs. There are already two plants in Sweden, one of which has been in operation for more than ten years ; others are under construction or planned. Such methods are also of special value in countries, like Venezuela, with rich ore and natural gas deposits ; however, they will need to be adapted to the particular conditions. The view once commonly held that steel produced from sponge iron is better, because of its purity, than that produced from scrap, is tenable if the scrap contains considerable impurities ; but there is no ground for regarding sponge iron as superior merely because it is " virgin iron."

The mass-production of steel is based on pig iron and scrap, i.e. on the one hand, by refining and removing most of the impurities from the pig iron and, on the other, by regenerating the scrap, which is already steel although not in usable form. The refining mainly consists of burning out the impurities ; the regeneration, in remelting the steel already there. The quickest and cheapest way of refining pig iron is at present the air-blast method, i.e. oxidation with atmospheric oxygen ; a large proportion of pig iron is, nevertheless, converted into steel by combining with oxygen in the open hearth furnace, which is a slow and expensive process. This essentially complicated method must be employed, since the hearth furnace is the scrap melter *par excellence* and open-hearth steel is in many respects superior to converter steel. The cause of the inferiority of the converter process can be traced to the air-blast, as under the present method, the nitrogen in the blast absorbs so much heat from the bath that the quantity of scrap (cold metal) that can be added is relatively negligible, and so much nitrogen enters into the steel that the latter contains substantially more nitrogen than open-hearth steel. By employing a blast rich in oxygen and a sufficiently low content of nitrogen, the heat absorbed by the nitrogen in the normal air-blast process remains in the steel, which then has a lower nitrogen content than open-hearth steel. This process has already been proved in small converters, both acid and basic ; tests have been made in an acid converter of 15 tons but there are still difficulties, although not of a fundamental character, in the way of applying the process in a large basic converter. As soon as they are overcome most of the scrap now remelted in the open-hearth furnace can be regenerated in the oxygen converter with the heat now lost due to the nitrogen in the air-blast.

In the basic electric-steel furnaces where relatively small quantities of pig iron (about one-quarter compared to scrap) are used, the blowing of oxygen is already in regular operation. The aim is not to speed up the refining of a bath of steel, as is being done in open-hearth and electric furnaces in many places, but to use the heat produced by the blowing of oxygen to melt the scrap and thereby correspondingly reduce electricity consumption.

There is no doubt that the use of oxygen as indicated is a practical possibility, and it lays the basis for consideration of the use of the heat produced by the blowing of oxygen for melting scrap, in the production of steel. As soon as this can be proved to be completely successful, all that is required for the production of molten steel is really only some sort of converter. In areas where electric power is cheap and there is more scrap than pig iron available, the electric steel furnace can be considered and function as a combined converter and electric furnace, consuming a small amount of electrical energy.

The transformation of iron production on the lines broadly indicated above will, in the long run, not only yield an intermediate metal of vastly different composition, but also have a marked effect on preliminary preparation of the materials ; the main objective to-day is to adapt the raw materials to the metallurgical processes, whereas it is wiser to suit the methods of treatment to the raw materials. In this connection, the first essential is to keep metal losses during treatment to a minimum and as far as possible to make treatment a part of the metallurgical process. The pelletisation method now being developed may be of considerable value.

For these reasons, and owing to the different composition of iron ores and fuels in the future, especially their higher silica content, the composition of the intermediate metal produced by smelting will differ more or less substantially from that of the normal pig iron, and in particular will generally have a very high silica content. This will not greatly complicate the application of oxygen-enriched blowing ; the heat required to reduce the silica thoroughly will be released during the blowing and therefore make it possible to feed more scrap to the furnace.

Although it will be many years yet before iron production is transformed on the lines indicated above, the necessary practical arrangements for the introduction of the new process should be made without delay. There is no lack of scepticism, as in the case of all striking new departures ; nevertheless, the ideas expressed above are no longer considered so Utopian as they were only a few years ago. But more urgent still than the earliest possible realisation of these ideas is the need to adapt the future processes of iron production to the raw material conditions of our earth.

A Manganese Bismuthide Permanent Magnetic Material

A MANGANESE bismuthide magnetic material which exhibits a coercive force of 3000 oersteds, has been developed by the Magnetics Division of the Naval Ordnance Laboratory at White Oak, Maryland. It has been called " Bismanol," Because of this very high coercive force, " Bismanol " is said to exceed any other permanent magnetic material except the platinum-cobalt alloy, in available flux density in short magnets where the length-to-diameter ratio is one or less. Since magnets of the new material are made by the powder metallurgy technique, complicated shapes can be processed to close tolerances without requiring machining. Manganese bismuthide was developed as part of a search for a magnetic material not containing nickel or cobalt, which could be compacted in the form of fine particles to form permanent magnets. This particular combination of materials was chosen by the Naval Ordnance Laboratory because of its potentially high magnetic crystal anisotropy. Both bismuth and manganese alone are non-magnetic. In the preparation of the magnetic alloy, powdered manganese and powdered bismuth are mixed and heated to about 700 deg. Cent. and aged at that temperature for from eight to sixteen hours. The alloy then consists of the intermetallic compound, manganese bismuthide, and unreacted manganese and bismuth. To obtain the enriched bismuthide from the mixture, the material is ground and the magnetic portions separated from the non-magnetic metals by a magnetic separator. The magnetic portion is then hot-pressed at a temperature of 300 deg. Cent. in a double-acting floating die in the presence of a strong magnetic field, which is used to align the particles along the direction of easy magnetism. Magnets made in this manner not only show a high coercive force but also have a maximum energy product comparable with " Alnico " magnets and have a Curie temperature of 350 deg. Cent.

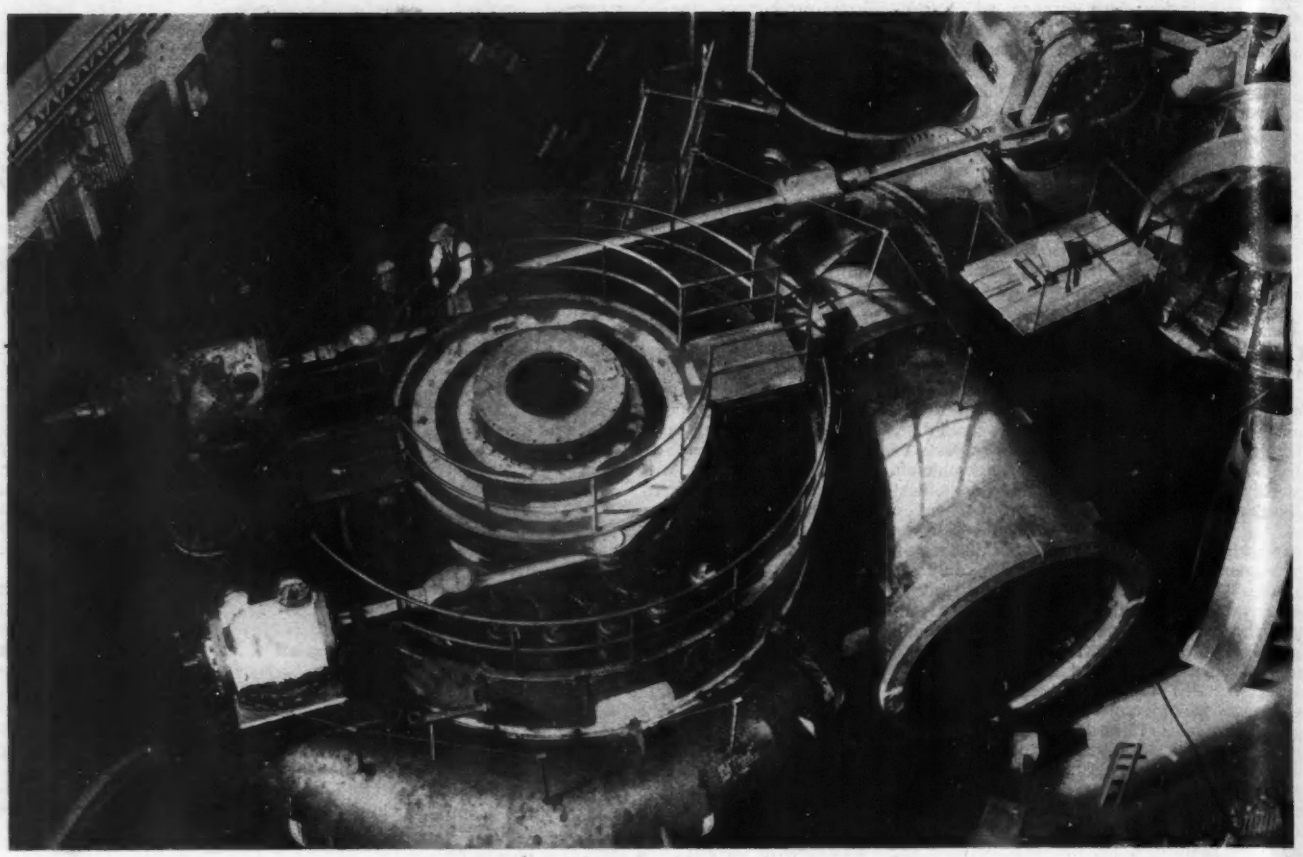


Fig. 1—Shop Assembly of a Turbine for Hoover Dam

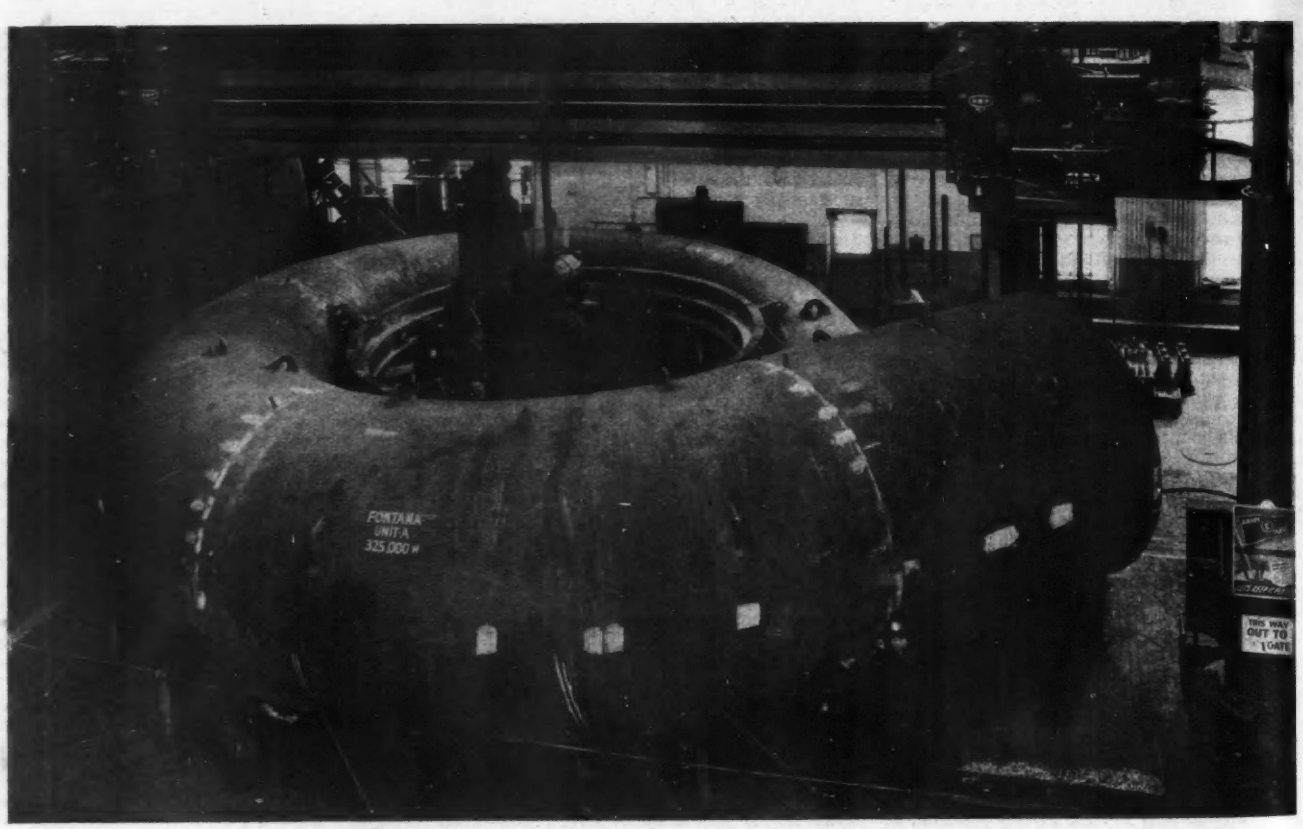


Fig. 2—Machining of Spiral Casing of Turbine for Fontana Power Station

Hydraulic Turbine Construction in America

(*By Our American Correspondent*)

In recent years there has been a pronounced tendency in the manufacture of hydraulic turbines to eliminate steel castings and to use welded steel plate in their place. In the case of Francis turbines, spiral casings, stay rings, head covers, bottom plates, discharge rings, wicket gates and even the runners themselves have been and are being fabricated. The Allis-Chalmers Manufacturing Company, of Milwaukee, Wisconsin, has been particularly active in the substitution of welded construction for castings, and the following details refer to some recent installations by that company.

IT has been established that by the use of welded steel plate in the place of castings, savings can be made in both the weight and the cost of a turbine. For hydraulic turbines, the usual maximum design stress employed in the United States for cast steel is 10,000 lb per square inch for both tension and compression; however, for steel plate it is 12,000 lb per square inch. This alone represents a possible saving of 17 per cent in the amount of steel required. A representative example of such a saving is furnished by the 115,000 h.p., 180 r.p.m., Francis turbines which have been supplied by the company for the power station of the Hoover dam of the U.S. Bureau of Reclamation. Seven of the original turbines have cast steel casings, while two recently installed units were equipped with fabricated steel casings. It is possible therefore for the manufacturer to make a direct comparison between the two types of construction, both as to weight and as to cost. Such a comparison has shown that the finished welded steel plate casing weighed 30 per cent less than the cast steel casing and cost 20 per cent less to manufacture, including the cost of the material. Since the spiral casings represent approximately 30 per cent of the total weight of the turbine and 25 per cent of the total cost, the saving in total weight of the turbine was 9 per cent and the saving in total cost was 5 per cent. In making the comparisons, allowance was made for the fact that the cast steel casings on the first seven units were slightly larger than the two welded casings. Fig. 1 shows the shop assembly of one of the Hoover dam turbines having a welded spiral casing, while Fig. 3 shows sections of the welded casing being set up for machining.

There was a further saving of approximately 3 per cent in the total cost of the turbines recently installed due to the fact that when the original turbines were built, steel foundries accepted skeleton patterns for making cast casings. At present, most American steel foundries insist upon solid patterns, which cost two to three times that of skeleton patterns. As shown in Fig. 1, the fabricated casing sections were constructed with flanges for bolting the sections together in the field. In the opinion of the company, a further saving estimated at 16 per cent in the weight of the casing and 30 per cent in the cost could have been obtained by omitting the flanges and designing the joints between the sections for field welding. This would have meant a saving of approximately 5 per cent in the total weight of the turbine and 7 per cent in the total cost. Therefore, turbines using welded steel casings with field-welded joints are likely to weigh about 14 per cent less than turbines with cast steel casings and flanged joints. Accompanying the saving in weight there is a possible saving of about 15 per cent in the total cost of the turbines. However, this saving is in the manufacturing cost and allowance must be made for the added erection costs due to field welding the joints between the casing sections. It has been estimated that for spiral casings similar to those furnished for the Hoover dam turbines, the cost of field welding would amount to approximately 2 per cent of the total cost of the turbine. Therefore, the overall saving would be about 13 per cent.

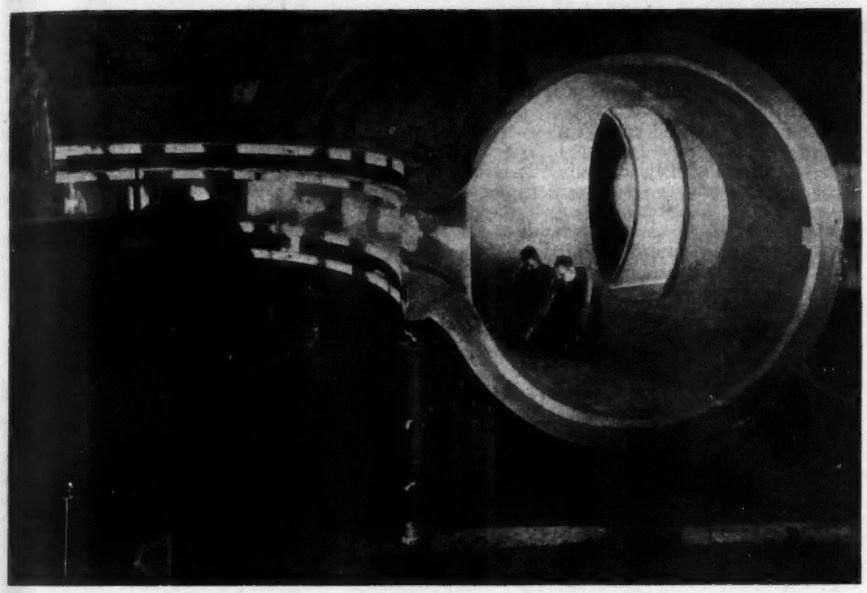


Fig. 3—Welded Turbine Casing Prior to Machining

Another advantage of the welded spiral casing as compared to the cast steel casing is the reduction in the likelihood of defective material being encountered. Recently, several large welded steel casings for use at comparatively high heads, such as the casings for the Gorge power station of the City of Seattle, Washington, were delivered to the site without a hydrostatic pressure test being conducted in the works of the manufacturer. Instead, this test was made in the field, permitting an earlier delivery and resulting in some saving in manufacturing cost. The manufacturer considered himself justified in taking this risk because of the nearly absolute assurance that the casings would not develop any leaks or flaws when pressure tested, a condition which was later confirmed by the actual tests in the field. These large savings in both weight and cost made possible by the use of fabricated casings for large turbines for medium and high heads have led to their increasing application by the company. Similarly, the use of field-welded joints in place of flanged or riveted joints has been advocated whenever possible. During recent years, a large number of the penstocks leading to turbines have been welded in the field, but, due to the limitations imposed by existing codes of practice, field welding of turbine scroll casings has not been permitted in very many American installations.

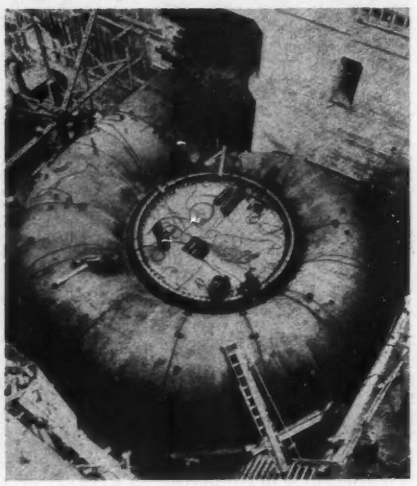


Fig. 4—Field Assembly of All-Welded Casing for Shipshaw Power Station

Some interesting exceptions to the latter are the turbines for the Fontana project of the T.V.A., the turbines for the Shipshaw power station of the Aluminum Company of Canada, and a turbine for the Cheoah power station of the Carolina Aluminum Company, which have been supplied with plate steel casings welded in the field. The Fontana project comprises two 91,500 h.p. turbines operating under gross heads which range from 245ft to 435ft, with 330ft being the rated head. The spiral casing, which is illustrated in Fig. 2, has a 12ft diameter inlet with the plate thickness varying from 1¼in to 1⅞in. The stay ring is of cast steel and is made up of five equal sections designed to be bolted together rigidly. The spiral casing is divided into eight sections, five sections corresponding to the five stay ring sections, and three being inlet sections. Since the highest stress in the casing occurs near the joints between the plate and the stay ring, the sections were designed so that all of these joints could be shop welded and could thus be furnace stress relieved. Each section consists of a number of plates with circumferential joints, which were shop welded. The circumferential joints between sections and some of the longitudinal joints in the inlet sections were welded in the field. All field welding was done under extensometer control. All welds were peened, the amount of peening being controlled by the extensometer readings. Specimens were cut daily from the work of each welder and tensile tests were made immediately on a portable testing machine. As a further test of the strength of all the welded joints, the casings were tested under a pressure of 375 lb per square inch, which is equivalent to twice the maximum static head. The first two units have been in satisfactory operation since 1945, and a third unit, equipped with a welded spiral casing and having its section joints arranged for field welding, has been ordered recently, and is now in the process of manufacture.

The turbine for the Cheoah power station of the Carolina Aluminum Company is rated 45,000 h.p. at a head of 188ft, and the inlet to

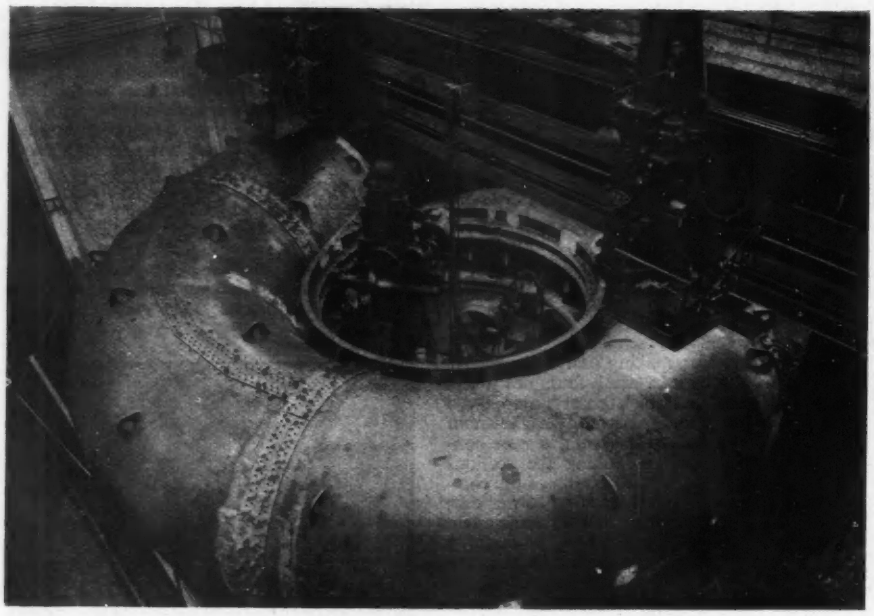


Fig. 5—Machining of Spiral Casing for Bull Shoals Development

the spiral casing is 12ft in diameter. This casing was welded entirely in the field, including all of the joints between plates and the joints between the plates and the stay rings. The unit has been in satisfactory operation since 1949. The Shipshaw power station on the Saguenay River in Quebec is believed to have been the first installation in North America to utilise spiral casings of all-welded construction. The scheme comprises twelve hydraulic turbines, eight of which are rated at 100,000 h.p. each at a head of 208ft, and four rated at 85,000 h.p. at a head of 208ft. The inlet diameter of the scroll casings is 16ft. All of the plates in the spiral casings in the eight 100,000 h.p. units were welded to each other and to the cast steel stay ring sections. The other four casings were constructed using riveted joints. Fig. 4 shows the assembly of one of the all-welded casings in the field prior

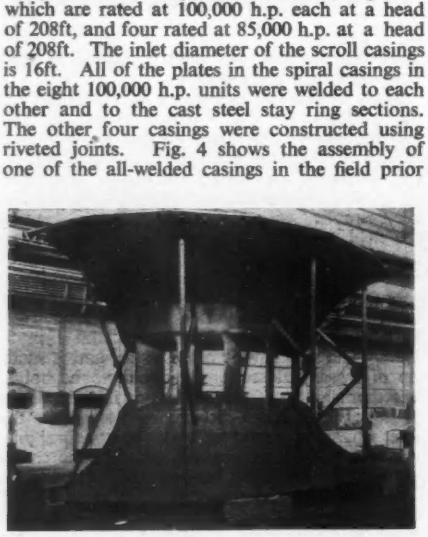


Fig. 6—Spiral Casing Section showing Joint between Stay Ring and Casing Plates

to the welding of the field joints. In this particular installation, no furnace stress relieving was used for either the shop or the field welds. The units were placed in operation during 1942 and 1943 and no trouble has been experienced with any of the welded joints. Although these installations proved the mechanical stress relieving of welds to be entirely satisfactory, a demand for thermal stress relieving is still frequently encountered. Recently, therefore, a controlled low-temperature method of stress relieving welds in place was devised by the company, which can be used to stress relieve field welds. Numerous tests have been, and are still being, made to determine whether this method is satisfactory, and while no definite conclusions have been reached yet, the results obtained so far are very promising. There is reason to believe that if this method should prove to be as effective as furnace stress relieving, a larger number of spiral casings of all-welded construction will be employed in the future.

Although the welded spiral casings are particularly advantageous for use in connection with large-capacity units operating at medium and high heads, welded construction also has proven to offer certain advantages when applied to the extremely large casings operating at lower heads. In the past, riveted joints in large casings have presented certain stress problems, and it was necessary frequently to make use of four and five rows of rivets and a double butt strap design. This situation has now largely been eliminated by using a welded joint at critical points. Fig. 5 shows an assembly of the 14ft 8in diameter inlet casing for one of the turbines supplied by the company for the Bull Shoals development of the U.S. Army Corps of Engineers on the White River in Arkansas. These turbines have a rating of 62,000 h.p. at a head of 190ft. Fig. 6 shows the welded joint between the steel plates and the stay ring. As many of the remainder of the casing joints as transport limitations permitted were shop welded in this particular case. Fig. 7 shows the assembly of one of the 19ft 9½in diameter inlet spiral casings for the Fort Randall reservoir project in South Dakota of the U.S. Army Corps of Engineers. These turbines are rated 57,500 h.p. at a 112ft head. Here, again, the critical joint between the casing and the stay ring is shop welded, as is shown in Fig. 8. The longitudinal joints designed for field riveting are situated at points where the stresses are lower, thus permitting a simpler type of joint. Due to transport limitations, it was again impossible to make use of completely welded sections.

As an example of the savings made possible by the use of welded construction, the shop welding on the spiral casings for the Bull Shoals turbines eliminated approximately 12,000 1¼in diameter rivets per casing. The cost of driving the remaining 3000 rivets per casing amounted to about 1 dollar per rivet. Therefore, the shop welding represented an approximate saving in field erection of 12,000 dollars per casing. There was an additional saving in the field erection in the elimination of the work necessary to assemble the plates preparatory to riveting and caulking the joints after the riveting was completed. This saving was estimated at an additional 7000 dollars per casing, making a total saving of 19,000 dollars in field erection and thus representing a saving of between 4 and 5 per cent of the total cost of the turbine.

The table herewith lists some of the large hydraulic turbines in North America which have been furnished with welded steel spiral casings, and having either riveted, flanged or field-welded joints between their individual sections.

Francis turbine runners are difficult to cast, and the price per pound of these castings in the United States exceeds the price for any other hydraulic turbine castings. Therefore, considerable thought has been given to the use of welded steel runners. Where a section through the runner bucket can be of constant thickness, such as for low-head installations, a fabricated runner presents no particular difficulty, and a number have accordingly been built. The buckets are die formed from steel plate and welded to steel plate or cast steel crowns and bands. However, for the higher heads, the runner buckets are required to be of varying thickness and are difficult to form out of steel plate, so that, up to the present time, fabricated Francis runners have been limited to low-head turbines. However, it is possible to cast the runner buckets separately to the proper shape and thickness and then weld them to the crown and band, permitting the use of simpler castings at a lower price per pound. This procedure also simplifies the work of grinding the bucket surfaces, and makes it possible to obtain uniform bucket thicknesses and discharge openings. A Francis runner having a 9ft 5in discharge diameter and weighing about 10 tons is, at present, being manufactured, using this method of construction.

In addition to the increasing use of fabricated steel plate construction in the manufacture of hydraulic turbines, there is a growing tendency towards the employment of stainless steel components. It has been established that stainless steels are not only able to resist the corrosive action due to chemicals in the water, but also resist the pitting action due to cavitation. The initial applications of stainless steel were mostly in the form of welded overlays on cast mild steel surfaces to repair pitted areas. After stainless steel had proved to be highly resistant to pitting, it was used for "prewelding" areas where it was anticipated that pitting would occur. Since a mild steel runner with stainless steel overlays is considerably less costly than a solid stainless steel runner, and since the use of stainless steel on Francis turbines has been increasing rapidly, attempts have been made to simplify the application of the overlays. A recent development has been the use of stainless steel strips welded to the surface of mild steel runner castings. This not

Some Hydraulic Turbines with Welded Spiral Casings

Power station	Number of units	H.P.	Head in feet	Casing inlet dia. ft in	Type of casing sections	Type of field joint
Aluminum Company of Canada, Shipshaw ...	8	100,000	208	16 0	Shop welded, stress relieved by peening	Field welded and peened
T.V.A., Fontana project	2	91,500	330	12 0	Shop welded, furnace stress relieved	Field welded and peened
Carolina Aluminum Company, Cheoah Unit No. 5	1	45,000	188	12 0	Field welded and peened	Field welded and peened
U.S. Bureau of Reclamation, Grand Coulee dam	9	165,000	330	15 0	Shop welded, furnace stress relieved	Flanged
U.S. Bureau of Reclamation, Hoover dam...	2	115,000	480	10 0	Shop welded, furnace stress relieved	Flanged
U.S. Bureau of Reclamation, Hungry Horse dam	4	105,000	400	11 0	Shop welded, furnace stress relieved	Flanged
City of Seattle, Gorge project...	1	82,500	280	12 6	Shop welded, furnace stress relieved	Flanged
U.S. Bureau of Reclamation, Shasta dam ...	5	103,000	330	12 3	Shop welded, furnace stress relieved	Riveted
U.S. Army Corps of Engineers, Bull Shoals development	4	62,000	190	14 8	Shop welded, furnace stress relieved	Riveted
U.S. Army Corps of Engineers, Fort Randall development	8	57,500	112	19 9½	Partly shop welded, furnace stress relieved	Riveted

Fig. 7—Shop Assembly of Spiral Casing for Fort Randall Development

only reduces the cost of surfacing with stainless steel, but ensures a uniform thickness of the overlay and acts as a guide to the true runner bucket shape during the grinding and finishing operations.

Solid stainless steel Francis runners, such as the one illustrated in Fig. 9, have been furnished by the company for a number of installations, and the use of such runners is recommended particularly for use in turbines operating at heads of above 600ft to 700ft. It is also desirable to use stainless steel wicket gates, facing plates and wearing rings for such high-head installations. Operating and maintenance experience with high-head Francis turbines has indicated that the additional initial cost of using stainless steel for these parts is well repaid in reduced maintenance and outage. Probably the largest items of maintenance coats on Francis turbines, next to the maintenance of the runner, are the wicket gate stems for both low-head and high-head installations. The wear on these parts is believed to be largely due to the corrosive action of the water. It has been found that the use of stainless steel sleeves for the stems tends to reduce such wear to a minimum and such sleeves have therefore been installed recently in a number of turbines.

Another source of damage to hydraulic turbines, which has been found to combine with cavitation and corrosion, is erosion caused by foreign matter in the water. When water flowing at high velocity carries hard materials such as sand, silt or glacial deposits, in suspension, the resulting damage can be rapid and severe. Unfortunately, both research tests and actual field operation have indicated that the 18–8 chromium-nickel stainless steels, which have a high resistance to pitting, do not have a very high resistance to erosion. In this respect, the stainless irons, with 12 to 14 per cent chromium content (equivalent to British " En 56 " quality), perform much better than the 18–8 chromium-nickel stainless steels. Other metals, which have shown promise concerning resistance to erosion, are the aluminium bronzes, particularly those which are produced in America under the trade name of " Ampco " bronze. A field test is being conducted to give a direct comparison between the resistance to both erosion and pitting of manganese bronze runners, 18–8 stainless steel runners, and " Ampco " bronze runners. These runners are installed in units which are subject to large quantities of highly abrasive sand being contained in the water. The original manganese bronze runners lasted only a short time, and after several extensive repairs had to be replaced about once every five years ; 18–8 stainless steel runners

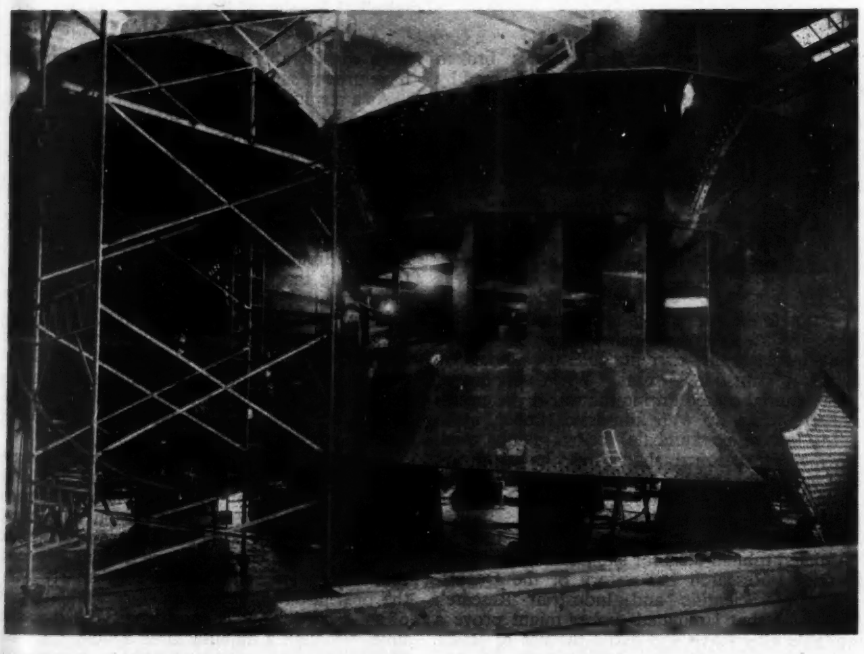


Fig. 8—Part of Spiral Casing for Fort Randall Development

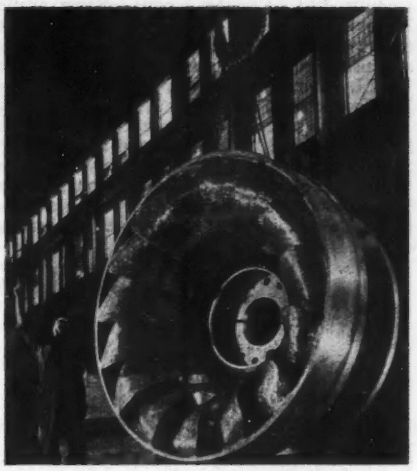


Fig. 9—Solid Stainless Steel Runner for Possum Kingdom Power Station

were installed about three years ago to replace two of the manganese bronze runners. These runners have stood up better than the manganese bronze runners and have shown no signs of pitting. They do, however, show evidence of sand erosion, although considerably less than that obtained on the manganese bronze runners during a similar period of time. " Ampco " bronze runners were installed about two years ago to replace the last two manganese bronze runners. These runners have stood up remarkably well during their two years of operation, showing no signs of either cavitation or erosion.

Aluminium Alloy Barges for Africa

WITH the issue by Lloyd's Register of Shipping of its " Tentative Rules for the Use of Aluminium in Ships " a few years ago, and also a list of approved manufacturers of aluminium alloys, such alloys have become increasingly accepted as a structural material for marine applications. A wide variety of craft incorporate light metal as part of their structure or equipment and the alloys have made steady progress, during the last few years, as a material suitable for the building of barges.

Last week we were able to inspect some barges which have been developed by Thorpe Brothers (Bessborough Works), Ltd., and built at the company's yard at West Molesey, Surrey. These craft, of all-aluminium alloy construction, are the last of an order for sixty barges for the Belgian Congo and are to be used for carrying general cargoes from the upper reaches of the rivers down to the coastal ports. For many years the work has been performed by locally built wooden barges of similar capacity, which suffered severe attacks from various marine borers such as the Teredo worm and Limnoria and had a service life of about three years. Protection against such attack by sheathing or other means proved costly and impermanent and, as the draught of the barges restricted the distance which they could travel up-stream during the dry weather, alternative construc-

tional material was considered. Steel barges suffered from corrosive attack from the Congo river water and had an average life of up to seven years. Steel was ruled out also on economic grounds, since the laden draught limited the operational period to about five months of the year, and so aluminium alloys were adopted. Their use, besides ensuring immunity from parasitic attack and freedom from corrosion, with a corresponding reduction in maintenance costs, made possible a loaded draught of some 10in less than the equivalent steel barge. This reduction in draught enabled the operational period to be extended to eight months and represented a great improvement in availability.

Previously to the present contract the company built ten light alloy barges each of 600 tons capacity, which were shipped out in pieces and reconstructed by native labour. Some of the barges of the present contract, which are of 60 tons capacity, have been constructed by welding and using a specially extruded section supplied by T.I. Aluminium Company, Ltd., as noted in THE ENGINEER of September 7, 1951. The latest design of this size of barge, illustrated herewith, has been named "Molesey" and is being built at a competitive cost by taking every advantage of the ease of working of the aluminium alloys. Other economies in building have been effected by the availability of large plates, measuring 30ft by 5ft, which has reduced the amount of jointing and simplified construction. Again, further savings have resulted from the ordering and delivery of both plates and sections to very close tolerances so that scrap has been reduced to a minimum, a vital consideration when using expensive materials such as aluminium alloys. The material, which has been supplied by the British Aluminium Company, Ltd., consists of plates in a non-heat-treatable alloy to standard specification N.P.5, and extrusions in the heat-treatable alloy HE 10.

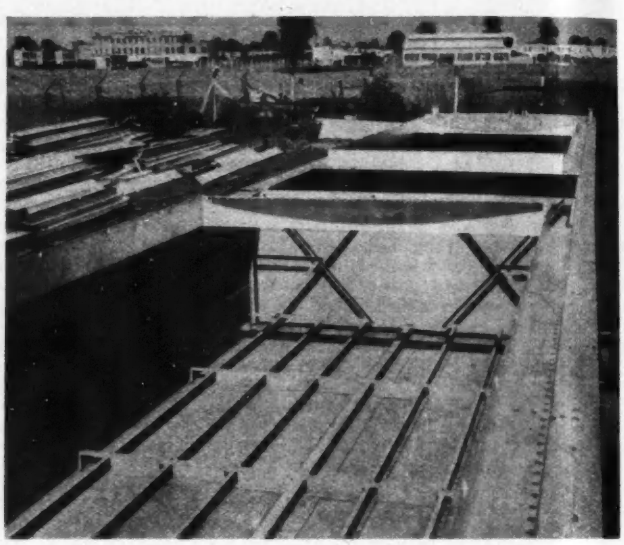
The barge has an overall length of 77ft by 11ft 6in beam and a depth to the gunwale of 4ft 6in, and has three water-tight bulkheads which form two holds and two peak compartments, each 8ft 6in long. Measuring 30ft in length, each hold has a capacity of 1320 cubic feet and, at a stowage rate of 40 cubic feet per ton, the barge can carry 66 tons, the loaded draught being 3ft 9in. Each hold is served by a hatchway having a clear opening of 18ft by 9ft.

SCANTLINGS

The longitudinal framing system has been adopted and the longitudinals, which are spaced 18in apart on the bottom, sides and deck, are of 3 $\frac{13}{16}$in by 1$\frac{1}{2}$in by 1$\frac{1}{2}$in by 0·25in Z bars, generally fastened to the plating by $\frac{7}{16}$in diameter rivets. Transverse framing is spaced 6ft apart and consists of a 3in by 1$\frac{1}{2}$in by $\frac{5}{16}$in ordinary angle face bar and angle bar intercostals of 5 $\frac{1}{16}$in by 1$\frac{1}{2}$in by 0·25in scantling. Throughout, the plating for bottom and side shell, deck and bulkheads is $\frac{1}{16}$in thick. The keelson is a special extrusion which has a bottom flange about 13in wide to form a connection with the bottom plating and joggled to give a flush seam. A section of similar scantlings is used to perform a similar duty as a deck king plate. Another special extrusion having a radius of 5in is used at the bilge and is joggled to take the bottom and side shell plating. The gunwale and deck margin is also a special extrusion, which is rabbeted to make a flush connection with the deck and side shell plating.

Sections having the same scantlings as the longitudinal framing and spaced 18in apart form the bulkhead stiffeners, while the bulkhead shell boundary bar is a Tee section 6in by 2in by 0·25in and the bar to the deck is a 2in by 2in by 0·25in ordinary angle. The hatch coamings are 8in high and consist of a special extrusion having a thickened top edge and a wide deck flange. Covers for the hatches are of aluminium alloy plate having cressed stiffening and flanged edges, which drop into transverse channel section supports having a camber of 6in in 9ft. Deck fittings are of galvanised steel and the twin timber bumpers, which are fitted at both the bow and the stern, are carried on rustproofed mild steel supports.

Barge ready for Shipping



Longitudinal Framing of Barge

For shipping overseas the barge is broken down into two halves, and the joint is formed by a Tee-section already riveted to one half. The midship length of deck plating, between hatch coamings, is in one piece and by overlapping the joint helps to form an efficient and strong connection between the two sections.

Laminated Shoebeams for Railway Rolling Stock

PRIOR to the war, high-grade naturally seasoned teak was used for the shoebeams which support and insulate the current collector shoes on London Transport's trains. When supplies of this material ceased during the war it was necessary to make do with kiln-dried timber, iroko (also known as kambala) being mainly used. Artificially seasoned shoebeams, however, are susceptible to splitting and other defects under arduous service conditions, and consideration was given to various substitutes.

Following the experimental use in 1946 of insulated tubular steel for shoebeams, the Forest Products Research Laboratory of the Department of Scientific and Industrial Research suggested that laminated timber might prove a suitable alternative and avoid the use of scarce materials. Shoebeams of this kind, it was pointed out, could be built up from small sections of timber bonded together with a weatherproof glue of synthetic resin, and the finished articles should have very good electrical and mechanical properties.

Four experimental beams were manufactured by the laboratory from English oak supplied by London Transport, a cold-setting phenol-formaldehyde resin glue being used. For purposes of comparison two beams had the glue lines in a vertical plane and two in a horizontal plane, whilst one beam of each type was of $\frac{1}{4}$in and the other of $\frac{3}{4}$in laminations, in all cases the grain running parallel to the neutral axis. The four beams were placed in service on similar cars in the middle of 1947. Up to date three of them have given no trouble, but the fourth—of which doubts were expressed at the time of manufacture—was found to have delaminated partially after some seven months' service.

In 1948 another experiment was initiated. One type of shoebeam in use on the Central Line has its centre section set up 1$\frac{1}{2}$in above the ends and the inclined portions of the beam are prone to splitting. It was thought that a laminated beam with vertical glue lines might overcome this difficulty, but the trial beams differed from those of the original experiment, in that they were necessarily of multi-ply construction instead of having all the laminations longitudinally grained. Birch was used instead of oak and the laminations were considerably thinner. So far these beams have proved satisfactory.

As a result of the trials substantial orders have been placed for laminated shoebeams for various types of car. The production beams are of plywood board, similar to that used in the Central Line experiment, built up from $^1/_{10}$in birch, ash or mahogany veneers bonded with phenolic resin glue, scarf jointing being permitted for all except the outermost veneers. The modern technique of radio frequency internal heating is employed for curing the glue lines, so completing within ten minutes a process which takes many hours using conventional heating methods. The beams are machined from the multi-ply board and drilled holes are fibre-bushed for insulation purposes. Clear phenol-formaldehyde varnish is applied as weatherproofing, instead of the black bitumen-based insulating varnish which was standard for solid beams.

Although plywood shoebeams are made from material of considerably less natural durability than that used for solid beams, London Transport considers that there is good reason to suppose that their performance under arduous service conditions will compare very favourably with that of existing solid beams, particularly when the present-day unreliability of available grades of solid hardwoods is considered. At the same time, although a manufactured article, the birch plywood beam is not appreciably more expensive than its solid iroko counterpart.

Industrial and Labour Notes

The Schuman Plan

The British delegation which will maintain contact with the High Authority of the European Coal and Steel Community has now been formed. A recent statement from the Foreign Office said that the delegation will form an intimate and enduring association between the Community and the United Kingdom, and will deal on a day-to-day basis with the many problems of common interest which will arise as the Community develops. The delegation was formed after Monsieur Monnet, chairman of the High Authority, had had talks at the Foreign Office about the question of British relationships with the newly constituted coal and steel community. Monsieur Monnet had stated, the Foreign Office announced, that the High Authority welcomed the position taken by the Government.

The United Kingdom delegation will be led by Sir Cecil Weir, who was at one time chairman of the Dollar Exports Board. It will include representatives of the Foreign Office, the Ministry of Fuel and Power, the Ministry of Supply, and delegates from the industries concerned—coal, iron and steel—of both management and labour.

The Price of Iron and Steel

The Ministry of Supply has announced that a new Iron and Steel Prices Order came into force on August 25th. The prices of certain qualities of alloy steel and stainless steel products have been revised to take account, amongst other factors, it is stated, of the changes in production caused by measures to conserve nickel and molybdenum, and also to take account of increases in the prices of alloy materials. The Order also removes blast-furnace ferro-manganese from statutory control, the price of which will in future be fixed by agreement between the makers and the Minister of Supply. Rainwater and soil goods, gutters and connections have also been removed from iron and steel price control; the Minister of Works will be responsible in future, it is stated, for pricing questions for these products. A number of other minor changes, including decreases in the prices of some galvanised articles to take account of the reduction of the price of zinc, have also been made. The Ministry states that the changes have been made in agreement with the Iron and Steel Corporation of Great Britain.

The Trades Union Congress

The annual congress of the Trades Union Congress is being held from September 1st to 5th, in Margate. The General Council's report, which is to be presented to the congress, has already been published, and contains some observations on the economic situation and the Trades Union Congress's attitude to it. It is pointed out that the General Council has approached the problem as trade unionists dealing with a trade union problem, and has kept in the forefront the basic aims of the trade union movement; it has been especially concerned to ensure that its policies were directed to the maintenance of full employment and living standards. The report includes criticisms of the Government's Budget policy, and remarks on the "denationalisation" of steel and road transport, which it considers as retrograde steps.

The report points out that Britain's economic position is as serious as at any time in the post-war period. It therefore gives an analysis of the relation between wages, profits and prices in the general problem, which is here quoted: "On balance," the report notes, "the factors making for further increases in costs and prices in the near future are likely to prove more persistent than are those making for an early depression of economic activity. This diversity in current industrial developments makes it especially necessary when reviewing the likely impact of wage increases on the economic situation to distinguish between their effect on demand and their effect on costs. Wage increases are unlikely to alter materially the pattern of demand. Consequently, most of the increased purchasing power would be used in buying those goods—the majority—for which demand is still relatively strong. Moreover, in so far as wage increases pushed up the cost of these latter items more than the cost of those for which demand is weak, this in itself would limit the extra money available for spending on such goods as textiles. As regards the effect on industrial costs, it is clear that in the absence of a rise in productivity, which cannot be expected to occur quickly, substantial wage increases are bound to raise costs. Moreover, it is likely that the largest wage increases would be secured in the industries whose products are most in demand at home and abroad; this likelihood is increased by the fact that, broadly speaking, it is in these industries that profits are highest. In other words, industrial costs are likely to increase most in precisely those industries on which we are most dependent for exports at the present time. It is impossible to avoid the conclusion that an appreciable increase in the cost of our exports at the present time might have the most serious consequences for our standard of living. There is, of course, no certainty that even if wage increases do not push up our export costs we shall be able to avoid further unpleasant measures in the near future."

Reference is made in the report to factors beyond the control of the Government or the trade union movement, but it is stated that rises in the cost of exports could in themselves price Britain out of world markets; this factor, the report notes, is largely within this country's control and, to some extent, within the control of the trade union movement.

Steel Supplies and Industrial Production

The current issue of the *Monthly Statistical Bulletin* of the British Iron and Steel Federation contains an article entitled "Steel Supplies and Industrial Production," which reviews the activities of the metal-using industries over the past few years, and gives some indication of what the position is likely to be in the future. The output of the metal-using industries, it is pointed out, has risen by more than 50 per cent since 1946, while their exports have about doubled over the same period. This expansion has been achieved with less than a proportionate increase in steel consumption, because economies in steel usage have been effected, and because there has been a shift in production to goods of higher value requiring less steel per pound sterling of output. Economies have been effected in usage due to the development of new sections, the development of high-tensile steel and steel with high corrosion resistance, and the use of welding, to give only some of the reasons. Productivity has risen by 20 per cent over the last sixteen years and, reckoned from the low level of 1946, 1951 shows a 30 per cent increase. Unless there are unforeseen difficulties with raw materials, the industry is confident that it can produce 16 million tons of steel this year. Allowing for second-hand and re-usable material, and an increase in imports, a total supply is thus in prospect of about 1 million ingot tons higher than in 1951, which, it is pointed out, should provide the basis for a considerable expansion in the output of the metal-using industries. Moreover, the anticipated further expansion of steel production to 20 million tons, it is remarked, should provide the basis for a continued increase in the output of the metal-using industries, assuming that overseas markets for metal goods can be expanded in an increasingly competitive world, and that the country chooses to set aside sufficient of its income to sustain a rising level of capital investment at home.

Iron and Steel Developments Overseas

On another page of this issue an article entitled "Possibilities of Development in the Production of Iron" is published, which has been abstracted from a report of the United Nations Economic Commission for Europe. This report is the first of a series "designed to assist business men, Government officials and professional economists to keep abreast of developments in basic iron and steel-making processes." It also includes articles on the expansion of the iron and steel industry in Canada; new production methods in Sweden; the replacement of coking coals in France; methods used in Germany to overcome the scarcity of fuel and to reduce costs; and developments in the Belgian iron and steel industry. Practically all of the six articles in the report refer to the three main technical developments in the industry, namely, improved ore-preparation methods, the use of top pressure in blast-furnaces, and the use of oxygen in the blast-furnaces and in steel-making processes.

The great interest for other countries with relatively cheap hydro-electric power, of utilising electric smelting furnaces for the reduction of ilmenite ores to produce two usable products, titanium and iron, is emphasised in the article on Canadian progress; the tunnel kiln process for making sponge iron is also commented upon. Developments in the methods used in Sweden include innovations in the preparation and treatment of ores, such as the new pelletising process and the method of dephosphorising ores by leaching, and various methods of reducing ores which economise in the use of coke and utilise lower grade fuels. The interest of Belgian technicians is concentrated on certain new furnace linings, recent research being directed to improving the quality of Thomas steels. In France the manufacture of coke from Saar Lorraine coals has progressed greatly during the past few years by three new processes, two of which have been perfected on an industrial scale; the extensive construction programme for coke ovens is leading to a considerable increase in the production of gas and other by-products. With respect to ore preparation and dressing, work carried out in Germany over the last few years to improve sinter has "been crowned with remarkable success," sintering capacity having been raised by 70 to 100 per cent with the same equipment.

Reduction in the Price of Brass

The Minister of Supply has made an Order reducing the prices of brass, brass scrap and gilding metal scrap to take account of the recent alterations in the Ministry of Materials selling price for virgin zinc which was noted in these columns recently. The prices of 60/40 brass and brass scrap have been reduced by £4 per ton, all other grades of brass and brass scrap by £3 per ton, and gilding metal scrap by £1 per ton.

Engineering Wages

For some weeks past we have noted on this page the events following the claim made by the Confederation of Shipbuilding and Engineering Unions on June 26th last for an increase in wages of £2 per week for all adult male workers in the engineering industry. It will be recalled that the claim was rejected by the Engineering and Allied Employers' National Federation, and subsequently discussed at the Confederation's annual meeting, when it was decided to approach the employers again. This approach took the form of a meeting which was held last Friday and at which the claim was again rejected. The Federation afterwards issued a statement to the effect that the negotiating committee maintained its view that the claim was unjustified, and was against the national interests inasmuch as any increase must increase costs. These costs could only be passed on to the consumer, the statement continued, meaning an increase in the cost-of-living and the cost of exports. Furthermore, it was pointed out in the statement that the claim was unwarranted by the rise in the cost-of-living which had been substantially met by compensations such as relief of income tax and the increase in family allowances. The committee could give no reason for giving a different reply, but it had undertaken to report the union's representations to the management board of the Federation, and to let the Confederation have an official answer in a week. It is understood that the claim was to be again discussed by the Confederation on August 31st.

Notes and Memoranda

Air and Water

LAID-UP TONNAGE.—The British tonnage laid up in British ports had risen by July 1st to 500,930 tons gross, as compared with 460,967 tons on April 1st and 362,879 tons on July 1st of last year. The corresponding figures for foreign ships laid up in British ports are 89,806 tons, 81,330 tons and 55,364 tons.

S.S. "FLANDRE" AND S.S. "ANTILLES."—The French state that the S.S. "Flandre" will be withdrawn from service for three months for the repair of mechanical trouble and will resume sailing in December. The maiden voyage of the S.S. "Antilles," announced for October 3rd, is postponed.

SIR GEORGE CRIBBETT, K.B.E., C.M.G., Deputy Secretary of the Ministry of Civil Aviation, left for Australia on August 16th to take part in discussions at Canberra with the Australian and New Zealand Ministers for Air on air transport problems of mutual interest to the three governments. The meeting will review the position of those air services in which the three governments are jointly interested and discuss further developments in their operation.

AIRCRAFT DOCKING FACILITIES.—In an article entitled "Aircraft Docking Facilities," published in our issue of August 8th, mention was made of two dock designs by Tiltman Langley Laboratories, Ltd., for nose-wheel and tail-wheel aircraft. We have been informed that it is a tail-wheel design which is being assembled under the supervision of that company (for B.E.A.) and not the nose-wheel version, which was illustrated in our article arranged round a model of the "Ambassador" airliner. The only dock for this latter type of aircraft at present under construction is one by the Heston Aircraft Company, Ltd., Heston Airport, Hounslow, Middlesex, to the design of and under the supervision of Wilson and Rodger, Consulting Engineers, Cinema Parade, Western Avenue, London, W.5.

Miscellanea

MAKING CONCRETE.—The July issue (No. 44) of the monthly digest issued by the Building Research Station is entitled "Making Concrete," and outlines some of the principles which must be observed to make a good concrete, describing a number of practical points for the concrete maker to watch, such as the quantity of water used and the proportioning of aggregates.

VITRIFIED TILES.—A vitrified buff-coloured tile suitable as a flooring surface particularly in chemical, food and other such factories, has now been added to the range of acid and alkali resisting bricks and tiles made by J. H. Sankey and Son, Ltd. The tile is dense and hard and has a non-slippery surface. It is made in two sizes, 9 7/16in by 4 1/4in by 1/2in and 9 7/16in by 4 1/4in by 1 1/2in, the weight per thousand being 1 ton 5 cwt and 2 tons 3 cwt, respectively.

TIMBER LICENCES.—The Ministry of Housing and Local Government states that some confusion has arisen over the correct procedure for applying for softwood licences in connection with housing. It has addressed a letter to all local authorities in the London Region drawing attention to the fact that applications for these licences for housing purposes should be made to the appropriate regional office of the Ministry and not to the offices of the Timber Control.

A QUARTERLY NEWSLETTER ON DIE-CASTING.—The Projectile and Engineering Company, Ltd., of Acre Street, London, S.W.8, is now publishing a quarterly newsletter for distribution to client's, existing and prospective customers and various branches of the trade and technical Press. The publication is intended to give information of developments in the firm's products, particularly injection moulding machines and die-casting machines; it will also include notes on the firm's social activities.

THE TREATMENT OF DRY ROT.—A revised edition of the Forest Products Research Bulletin, No. 1, "Dry Rot in Wood" (price 2s.), has been published by H.M. Stationery Office. It contains complete information on how to recognise a dry rot attack and what to do about it before it becomes extensive and expensive. The bulletin describes practical methods of detecting and treating the decay. Other fungi which cause decay of wood in buildings are dealt with comprehensively in the bulletin, a treatment which, in earlier editions, has proved of value.

CLERICAL SALARIES ANALYSIS.—The Office Management Association has published a report entitled "Clerical Salaries Analysis," relating to the salaries of clerks at March, 1952. The first analysis of the kind was prepared in 1942, when the salary scales of 18,550 clerks were surveyed. The present report covers 56,414 clerks. The many tables included in the report deal with clerical salary trends in the various industrial groups and regions of this country. They also deal with the salary scales of Government and other large organisations. The report, which costs 25s., is available from the Office Management Association, 8, Hill Street, London, W.1.

ACCIDENT TO A TOWER CRANE.—A short while ago prominence was given in the daily Press to an accident in which a tower crane in use on a building site in London was involved. The crane was one made by Jules Weitz, of Lyons, and was of lattice construction consisting of a tower with a fixed cantilever and having a driver's cabin which travelled up and down inside the tower. For transport purposes the cranes are built in sections and each part of the tower is, on site, secured to the adjoining sections by bolted fishplates. When a crane is dismantled crossbars at the joints are removed and replaced again on re-erection. At the time of the accident the crane was turning when, without warning, the tower started to bend at the centre just above the cab, and it finished up in the form of a "V" with the head resting upon the ground. An examination by an independent consulting engineer and representatives of the makers showed that the crossbar at the point where the bend occurred was missing. This bar was subsequently found in the driver's cab, and the driver admitted removing it because, he said, the bright aluminium paint dazzled him and interrupted his field of vision. The reason why the driver did not raise or lower his cabin to get the clear field of vision he required is not given.

A PNEUMATIC VIBRATOR.—We have received details of a 4in diameter pneumatic internal vibrator made by Compactors Engineering, Ltd., 1a, Brailsford Road, London, S.W.2. This tool is designed for mass concrete and heavy reinforced concrete construction work. Suited for air pressures from 75 lb to 100 lb per square inch it consumes about 60 cubic feet per minute at 90 lb per square inch pressure. The vibrating head is 20in long by 4in diameter and has a cylinder and toe-piece of hardened wear-resisting steel. A four-vane air motor drives the eccentric at speeds, which can be controlled by a speed regulator, up to 9000 r.p.m. The total weight of the tool is 60 lb, which includes 10ft of hose, throttle handle and lubricator.

TRUNK AND AUTO-MANUAL EXCHANGES.—The Automatic Telephone and Electric Company, Ltd., Strowger Works, Liverpool, 7, has just issued its engineering bulletin No. 523 on trunk and auto-manual exchanges. This bulletin describes trunk and auto-manual exchange switchboards of sleeve control design as installed in large director telephone areas. The various facilities available and the class of service provided, including demand and relay trunk working, assistance, information, directory inquiry and phonograms, are outlined and explained. Reference is also made to keysending positions and desks associated with these exchanges. Mention is also made of ticket distribution by conveyor bands or pneumatic tubes, voice frequency signalling and testing equipment.

UNIVERSAL DIRECT READING INDICATORS.—The 1950–51 report of the Medical Research Council described the development of a new machine tool setting device by its Applied Psychology Research Unit. We are informed by English Numbering Machines, Ltd., of Queensway, Enfield, Middlesex, that it co-operated in the development of these universal direct reading indicators. This firm has the commercial application of the instruments, together with the exclusive rights for their manufacture. Patent rights for the indicators are pending in a number of countries and we understand that the company will shortly be producing a range of models suitable for a variety of machines. With these new instruments it is stated to be possible to set machines to accurate limits without hesitation or mental arithmetic, and to attain substantial savings in setting times with almost complete elimination of human errors.

DESIGN OF WELDED STRUCTURES.—Courses on welding design organised by the Quasi-Arc Company have been held regularly each year at London and Bilston. This scheme is being extended to other industrial centres and a course has been arranged for this year in Newcastle. The lectures will be given on Tuesday and Wednesday evenings, over six weeks commencing October 14, 1952, at King's College, Newcastle. Throughout the course the instruction concentrates on the needs of draughtsmen; particular emphasis is placed on the practical factors involved in designing welded structures and the efficient detailing of all types of welded structural components. Further details of the course along with the enrolment forms can be obtained on application to the Constructional Design Department, the Quasi-Arc Company Ltd., Bilston, Staffs.

LECTURES ON TOLERANCES, LIMITS AND FITS.—The Engineering Production Department of the Northampton Polytechnic has arranged a course of lectures on tolerances, limits and fits and their application to engineering design and manufacture. The course is intended to cover the two new British Standards B.S. 308, Part II, "Engineering Drawing-Office Practice, Dimensioning and Tolerancing," and B.S. 164, Part I, "Limits and Fits for Engineering." It will consist of three separate subjects, dimensioning and tolerancing, limits and fits, and engineering metrology, and whilst the three subjects are intended to form a balanced course, they may be taken separately or collectively as desired. Each class will be held one evening per week for twenty weeks during weeks commencing October 6, 1952, to December 15, 1952, inclusive, and January 5, 1953, to March 2, 1953, inclusive.

WORKS MANAGERS' CONFERENCE.—The twenty-first annual conference of the Institution of Works Managers is to be held at the Town Hall, Birmingham, from Thursday to Saturday, October 18th. The theme of the conference is to be "Management's Objectives" and papers on several aspects of management and training are being presented. A reception is arranged to take place, followed by a works visit on Thursday at the Grand Hotel. During the Friday sessions a paper entitled "The Road for Management" will be presented at 10.15 a.m. by A. B. Waring, of Joseph Lucas, Ltd., and the Rt. Hon. Sir Walter Monckton, Q.C., M.P., will give an address entitled "Guide to Management." "Technical Training and Education for the Future" is the title of a joint paper by Professor P. Sargent Florence and Professor T. V. Matthew, to be presented on the Saturday morning session at 10 a.m., and the final session will include a paper by W. R. P. King on "The Work of Advisory Panels."

Personal and Business

MATTHEW HALL AND CO., Ltd., announces that Mr. E. C. Pledger, A.M.I.H.V.E., has been transferred to the Johannesburg offices of Matthew Hall (Pty.), Ltd.

THE RESEARCH AND DEVELOPMENT DIVISION of the British Steel Founders' Association announces that Mr. F. Marshall, B.Met., has joined the Division's metallurgical staff.

THE PLESSEY COMPANY, Ltd., announces that Mr. J. Foster Veevers, M.I.E.E., M.I.P.E., M.I.I.A., has been appointed general manager of the company's Swindon works. Previous to joining the Plessey Company, Mr. Foster Veevers was with the General Electric Company, Ltd., as manager of the Stockport works of Salford Electrical Instruments, Ltd.

MR. F. AUSTIN, at present works manager of the factory of Hoover, Ltd., at High Wycombe, Bucks, will on September 1st move to the firm's Merthyr Tydfil factory, where he has been promoted to the position of works manager to assist Mr. A. R. Northover, the resident director and manager. Mr. J. Hallifax, superintendent at High Wycombe, will, from September 1st, take charge of the High Wycombe factory.

Contracts

THE DE HAVILLAND AIRCRAFT COMPANY announces that it has received orders from Japan for two "Comet" Series 2 jet airliners, three four-engined "Heron" feeder-line transports and four twin-engined "Dove" light transports.

THE ANGLO-SAXON PETROLEUM COMPANY, Ltd., has placed orders, to a value of about £20,000,000, for a total of nineteen ships, ten of which are to be built in Great Britain. Of the remaining vessels Dutch shipyards are to build seven ships, consisting of one of 31,000 tons deadweight, three of 18,000 tons deadweight, and three of 12,000 tons deadweight, and two bitumen carriers of 15,000 tons deadweight are to be constructed in Germany. Four of the orders placed in Great Britain are for ships of 31,000 tons deadweight and one each have been ordered from Swan, Hunter and Wigham Richardson, Ltd., Wallsend; R. and W. Hawthorn Leslie and Co., Ltd., Hebburn; Harland and Wolff, Belfast, and Cammell Laird and Co., Ltd., Birkenhead. The remaining six ships are of 18,000 tons deadweight and R. and W. Hawthorn Leslie Company, Ltd., J. L. Thompson and Sons, Ltd., Sunderland, Lithgows, Ltd., Port Glasgow, and Cammell Laird and Co., Ltd., are to lay down one each and Smith's Dock Company, Ltd., Middlesbrough, has received the order for two.

Catalogues

HIGGS MOTORS, Ltd., Birmingham, 6.—Abridged price list.

ARCOLECTRIC SWITCHES, Ltd., Central Avenue, West Molesey, Surrey.—Price List No. 127.

MERITUS (BARNET), Ltd., Barnet, Herts.—Pamphlet describing Type H.S.10 portable plier welder.

H. H. STARK, Ltd., 193, Whitechapel Road, London, E.1.—Catalogue of trucks for all purposes.

BIRLEC, Ltd., Erdington, Birmingham, 24.—Leaflets describing induction heating units and their uses.

HOUCHIN, Ltd., 447, Grand Buildings, London, W.C.2.—Pamphlet dealing with six-cylinder vertical diesel engines.

EUMUCO (ENGLAND), Ltd., 12, Great Portland Street, London, W.1.—Catalogue illustrating mechanical forging equipment.

ROCKWELD, Ltd., Commerce Way, Croydon, Surrey.—Booklet describing additions to the range of stainless steel electrodes.

ENGINEERING DIAMONDS, Ltd., 26, Warwick Row, Coventry.—Leaflet describing the Endia standard diamond chisels.

NEWBURY DIESEL COMPANY, Ltd., Kings Road, Newbury.—Pamphlet illustrating the "Sirron" range of high speed diesels.

CARTER GEARS, Ltd., Thornbury Road, Bradford, Yorks.—Leaflet giving details of fractional h.p., infinitely variable speed gear.

SIEBE GORMAN AND CO., Ltd., Neptune Works, Davis Road, Tolworth, Surrey.—Leaflet describing the "Microfilter" dust respirator.

ELTRON (LONDON), Ltd., Accrington Works, Strathmore Road, Croydon, Surrey.—Leaflet giving particulars of heating elements.

BRONX ENGINEERING COMPANY, Ltd., Lye, Nr. Stourbridge.—New operating and maintenance manual for "Bronx" Press Brakes.

BIRLEC, Ltd., Erdington, Birmingham, 24.—Three leaflets illustrating Lectrodryer Moisture Adsorbers, Lectrodryers for low humidity conditions and Lectrofilters for removing oil from compressed air.

REDFERN'S RUBBER WORKS, Ltd., Hyde, Cheshire.—Two leaflets, one dealing with resistance to chemical action of rubber and ebonite, the other describing extruded sections in natural and synthetic rubbers.

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., 21, Bloomsbury Street, London, W.C.1.—Callender-Hamilton Bridge Handbook, 1952, dealing with the Highway Bridges, Type "B," with brief illustrated references to other types.

British Patent Specifications

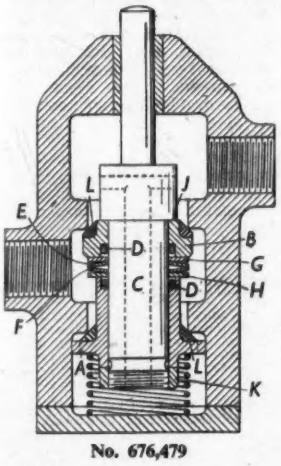
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 6d. each.

VALVES

676,479. April 21, 1950.—Double Beat or Equilibrium Valves, The Hymatic Engineering Company, Ltd., Glover Street, Redditch, Worcestershire. (*Inventors: James Bertram Jay, Albert Joseph White and Joseph Anthony Hunt.*)

The object of the invention is to provide an improved construction of double beat or equilibrium valve which can be in balance and is capable of fine adjustment, so that a seal is obtained simultaneously at both valve seats. As shown in the drawing, the two valve heads *A* and *B* are each a good sliding fit upon the valve spindle *C*, and a fluid-tight joint is made between each valve head and the spindle by a packing



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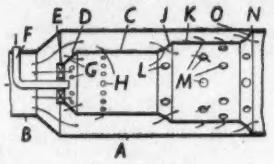
ring *D*. Belleville washers *E* and *F* are arranged between the valve heads with plain rings *G* and *H* between the washers and the valve heads, preventing displacement of the packing rings from the recesses. A shoulder *J* on the valve spindle against which the valve head *B* bears and a nut *K* which screws on the end of the spindle *C* presses directly upon the valve head *A* and determines the distance between the seating surfaces *L* of the valve heads and the degree of pressure applied to the Belleville washers. The seating surfaces *L* upon the valve heads may be made of rubber or other material. The load exerted by the Belleville washers between the valve heads is so much greater than that produced by fluid pressure acting on the opposite ends of the valve heads tending to press the heads towards one another, that the valve assembly is virtually solid. The flexibility of the Belleville washers enables a simultaneous seal to be made at each seating surface, whilst the packing rings prevent leakage between the valve heads and the spindle so that the valve forms an effective seal.—*July* 30, 1952.

GAS TURBINES

676,473. March 7, 1950.—Combustion Chambers, Ricardo and Co., Engineers, 1927, Ltd., 21, Suffolk Street, Pall Mall, London, S.W.1. (*Inventors: Harry Ralph Ricardo and John Forster Alcock.*)

In combustion chamber assemblies used in gas turbines, it is usual to provide a small excess of air in the primary combustion zone or chamber so that the hot gases leave this chamber at about 1500 deg. to 2000 deg. Cent., this hot gas being diluted in the dilution zone or chamber with cool air at about 200 deg. to 400 deg. Cent., to form a mixture for delivery to the turbine at a temperature of between 600 deg. and 700 deg. Cent. The object of the invention is to provide an improved combustion chamber assembly of the kind which will tend to avoid the presence of a hot core in the gases finally leaving the assembly. In the construction shown in the drawing the assembly comprises a tubular outer casing *A* into the inlet end of which leads an air delivery passage *B* from the usual air compressor of a gas turbine unit. Supported within the tubular casing is a combustion chamber *C* having a short frusto-conical section *D* at its inlet and terminating in an inlet aperture containing a ring of swirl-producing guide vanes *E*, in the centre of which ring lies a fuel injection device receiving fuel from a pipe *F* passing through the wall of the air delivery passage. The combustion chamber is provided in addition with air inlet holes *G* and *H* as indicated. The outlet end of the combustion chamber is connected by a short frusto-conical section *J* to a tubular dilution chamber *K*, air inlet apertures *L* and *M* being formed in the wall of the frusto-conical portion *J* and the wall of the dilution chamber. The outlet end of the dilution chamber is connected to the wall of the tubular casing *A* by a frusto-conical section *N* in which there are further



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air inlet apertures *O*. Thus, part of the air delivered through the air passage *B* passes through the guide vanes *E* and the air inlet apertures *G* and *H*, and is burnt in the combustion chamber *C*, while the remainder of the air passing on through the casing *B* enters the dilution chamber *K* through the apertures *L M N* to mix with the products of combustion and any unburnt fuel or unconsumed air from the combustion chamber *C*. Modified designs are also shown in this specification.—*July* 30, 1952.

WORKSHOP TOOLS AND APPLIANCES

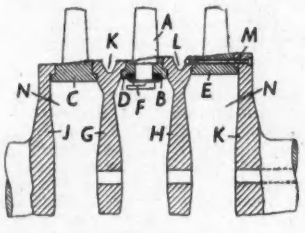
676,476. March 17, 1950.—Soldering Iron Bits, John Lawrence Drury Oakley, Lloyd Wise, Bouly and Haig, 10, New Court, Lincoln's Inn, London, W.C.2, Chartered Patent Agents. (*Communicated by Edward Magnus Julius Hansen, Borupsalle 200, Copenhagen, Denmark.*)

The object of the invention is to produce a soldering iron bit which holds the tinning, even if the bit is overheated. According to the invention a soldering iron bit consists wholly or partly of brass and at least its point consists of brass without impurities or with very few impurities and comprises 58 to 65 per cent copper and 35 to 42 per cent zinc and silicon up to 5 per cent. It has been proved that soldering iron bits having at least the point, i.e. the soldering surface, made of brass of this type can stand an overheating even to very high temperatures without the tinning being damaged thereby. Further, tin may be contained in the brass so that the total of silicon and tin does not exceed 7 per cent and individually they do not exceed 5 per cent, for example, up to 5 per cent tin with 0·5 per cent silicon. With such constituents the overheating qualities of the soldering iron bit and its capability of holding the tinning are further improved. It has been found that a soldering iron bit (being essentially made of copper but having the point made of brass comprising about 60 per cent copper, about 39 per cent zinc, about 0·5 per cent silicon, and about 0·5 per cent tin) can stand being heated to white heat without losing the tinning. This bit has also proved to be effective for several days at a time without being refiled and retinned.—*July* 30, 1952.

TURBINES AND COMPRESSORS

676,589. August 23, 1950.—Axially Connected Rotors for Multi-Stage Axial-Flow Turbines and Compressors, Escher Wyss Aiktengesellschaft, Escher Wyss Platz, Zurich, Switzerland.

As shown in the drawing, the rotor blades *A* of each compression stage are adjustably mounted on ball bearings *B* in a ring formed in one piece *C*, *D* and *E*, as illustrated in connection with the blade *A* of the second stage. An adjusting mechanism engages with part *F* of these blades. The two adjacent rings *C* and *D* are held by a common disc *G* and the two adja-



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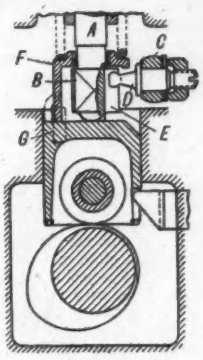
cent rings *D* and *E* are held by a common disc *H*. The two end rings *C* and *E* are each held by end discs *J* and *K*, respectively on their outer sides. The end discs are integral with stub shafts. The supporting discs *G* and *H* have on their peripheries annular grooves *K* and *L*. Each of the rings is detachably held together with the supporting discs by bolts *M*. As shown, ample free space *N* is provided in the interior of the rotor described, in the extension of the longitudinal axes of the rotor blades of the individual stages, so that there is no difficulty in accommodating parts of the mechanism required for the adjustment of the rotor blades.—*July* 30, 1952.

INTERNAL COMBUSTION ENGINES

676,051. July 3, 1950.—Fuel Injection Pump, Klockner-Humboldt-Deutz, A.G., Koln 22c, Germany.

The drawing shows a part of the fuel injection pump in vertical section. It is one in which the plunger *A* is rotated about its axis for the purpose of regulating the quantity of fuel injected, and, for this purpose, has the crosshead *B* coupled to a regulating rod *C*. The regulating rod has a knuckle pin *D* with an enlarged spherical forward end or knuckle which



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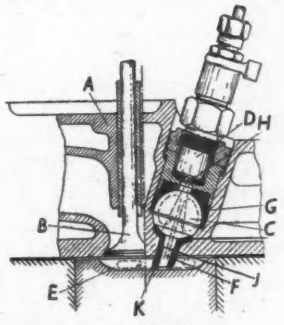
can slide in a vertical slot *E* formed in the crosshead. The plunger is driven by a cam through a guide in which is mounted a roller which tracks the edge of the cam. It is driven by the cam only during the delivery stroke. During the suction stroke the plunger is returned by a spring, shown dotted, which bears against a spring plate *F*. The plate has a downwardly directed sleeve extension bearing against the guide on which the spring plate is centred and secured against rotation by means of the pins *G*. The stages of the plunger rotation are shown in the specification. A clearance opening in the spring plate enables the crosshead to be passed through the clearance opening and withdrawn from the pump.—*July* 23, 1952.

677,020. September 30, 1949.—Precombustion Chambers for Internal Combustion Engines, Daimler-Benz Aktiengesellschaft, Stuttgart, Unterturkheim, Germany.

The object of the invention is to facilitate starting at low temperatures without having to resort to auxiliary means. The engine illustrated is a vehicle diesel engine with a water-cooled cylinder head *A* with two valves. Only one valve *B* is shown. The precombustion chamber *C* is arranged opposite the



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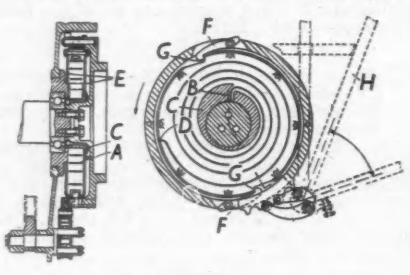
valve *B* and is situated in an oblique bore in the cylinder head. The chamber is charged with fuel by the injector nozzle *D* and receives air from the main combustion space *E* by a passage *F*. The passage *F* is a cylindrical bore and of a length greater than its diameter, which is necessary for delivering, during the compression stroke, a well-defined stream towards the injection nozzle. The precombustion chamber *C* is spherical and in accordance with the invention that portion of this chamber adjacent to the injection nozzle *D* is enclosed by a cup-shaped liner *G* of heat insulating material inserted in the cylinder head, the part-spherical interior of this part being presented towards the passage *F*. During the compression stroke the air stream delivered by the passage makes impact with the part-spherical interior and is deflected thereby in all directions away from the injection nozzle so that a

whirl of annular form is set up in the precombustion space. The liner *G* is insulated from the surrounding cooled wall of the cylinder head by a cylindrical gap and by a disc-shaped gap above from the sleeve. The arrangement is clearly shown in the drawing. The fuel jet is injected through a central passage *H*, as indicated by the divergent dotted lines, into the opposed air inflow which is deflected by the liner *G*. The fuel then becomes ignited in the vicinity of the opposite wall area of the chamber *C*. This wall area, together with the wall enclosing the flow passage *F*, is formed by a cylindrical liner *J*, which is splayed to form a portion of the spherical shape of the chamber. It is extended so as to project beyond the underside of the cylinder head and into the main combustion space. When the piston is at the top of its stroke there is produced a narrow annular gap *K*, through which the contents of the precombustion chamber *C*, blown out after ignition, are distributed radially, as indicated by the dotted arrows in the main combustion space *E* and uniformly throughout the space. In this manner, and in combination with the gentle precombustion chamber ignition, a gentle and complete combustion with a high degree of efficiency is obtained.—*August* 6, 1952.

676,850. September 18, 1950.—SPRING STARTER FOR AN INTERNAL COMBUSTION ENGINE, Klockner-Humboldt-Deutz, A.G., Cologne, Germany.

Mounted on the engine frame is the crankshaft which carries at one end the flywheel. Only one roller bearing held in a plate of the frame is shown. Between the frame and flywheel is arranged the spring driven starter which has as a power accumulator a spiral spring *A* surrounding the crankshaft. The spring is wound up in the direction opposite to the operational direction of rotation of the engine crankshaft and is secured at its inner end *B* to a boss *C* on the bearing plate, and thus to the engine frame. The spiral spring is secured at its outer end *D* in a rotatable housing *E* which surrounds it. The housing is mounted on the boss on the bearing plate. On the flywheel are fixed two diametrically opposite pawls *F*, which, when the flywheel is moved in the direction opposite to the operational direction of rotation of the engine crankshaft, engage in notches *G* in the rotatable housing after rotation through a certain angle, and also turn this housing in a direction opposite to the operational direction of rotation of the engine crankshaft, whereby the spiral spring is wound and tensioned. When the tension of the spring has become so great that it is sufficient to start the motor, the drive of the flywheel is disengaged.



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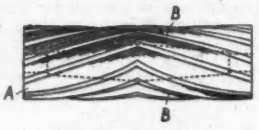
At this instant the spiral spring is released, and in expanding, it momentarily greatly accelerates the flywheel and the engine is started. When the engine speed increases, the pawls are brought out of engagement by centrifugal force. The device shown in the drawings for the flywheel is a manual drive, which can conveniently be replaced by an electric motor drive or other power drive. In order to drive the flywheel the hand lever *H* is rocked to and fro through the angle shown. When the hand lever is moved into the vertical position shown in dot-and-dash lines the drive of the flywheel is disengaged, and the spiral spring is released for starting the engine.—The invention is not limited to a spiral spring, but is also applicable to spring starters comprising helical torque springs.—*August* 6, 1952.

MISCELLANEOUS

676,475. March 16, 1950.—ROLLERS FOR SUPPORTING CONVEYORS, C. H. Johnson (Machinery), Ltd., Adswood Road, Stockport. (*Inventor: Hannah Josephine Bradshaw.*)

The object of the invention is to provide improved forms of drum by which there is less tendency to damage the belt; by which the belt is kept central lengthwise of the drum, and more particularly by which any material finding its way below the belt and between the belt and the drum is effectively and automatically removed. In the form shown in the drawing, the drum is a casting, and in practice might be 7½in overall diameter when machined. The length may vary, say, from 12in to 24in, or longer. In the circumference of the drum are twelve grooves *A* forming twelve teeth *B* of double helical form, a helix angle of 60 deg. or thereabouts. Each tooth *B* has tapered sides at the centre of the drum, and the bottoms of the grooves are rounded. At the ends of the drum, the teeth have parallel sides. At the centre of the length



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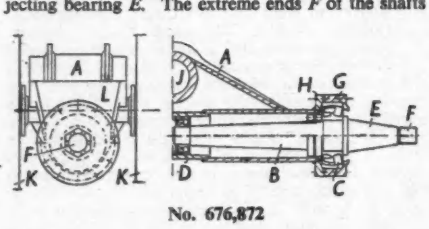
of the drum the teeth are of less height than at the ends. At the ends the teeth are of a parallel cross-section, equal in thickness to the width of their tips, which is uniform throughout their length. The difference in height is due to the grooves becoming deeper from the centre to the ends, the tips of the teeth remaining parallel with the axis of the drum. The drum is mounted so that, when rotating in use, the centres of the teeth lead.—*July* 30, 1952.

ROAD TRANSPORT

676,872. March 17, 1949.—ROAD VEHICLE BOGIE CONSTRUCTIONS, Cranes (Dereham), Ltd., South Green Works, Dereham, Norfolk. (*Inventor: William David Chaplin.*)

Referring to the drawings, the bogie beam *A* is hollow and carries two shafts *B*, each running in roller bearings *C* and *D* and having a tapered projecting bearing *E*. The extreme ends *F* of the shafts



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are screwed. The bearings are each surrounded by a two-part casing *G* and *H*, which excludes dust. The part *H* is secured to the end of the hollow beam *A* and the part *G* is bolted to it. The bogie beam is mounted on a shaft *J*, on which it pivots. Pairs of wheels *K* are carried on axles mounted at the ends of the bogie beam. On each bearing *E* there is fixed a bearing member *L*, in which is mounted the axle connecting the pair of wheels *K*.—*August* 6, 1952.

Technical Reports

Excitation Temperatures of Hydrogen Arcs (Ref. L/T 255). By H. Edels and J. D. Craggs. The British Electrical and Allied Industries Research Association. Price 12s., postage 4d.—The measurements described in this report were undertaken as part of a larger programme of work on the d.c. hydrogen arc which is partly intended to show by means of measurements of excitation, electron and gas temperatures on the same type of arc how nearly the state of thermal equilibrium is approached. The data are also of interest for other reasons, e.g. because excitation processes in high pressure discharges have been seldom studied in detail. Measurements of the relative intensities of the first three Balmer Series lines (Hα, Hβ and Hγ) excited in low-current (up to 10A) d.c. arcs in hydrogen are described. The pressure range was from 1–2 atmospheres. The results, after correction for self-absorption, show that the populations of the appropriate excited states are not those given by a Boltzmann distribution, i.e. the data obtained cannot be described in terms of a single excitation temperature. Possible causes of this effect are briefly described.

Network Analyser: Inherent Restriking Voltage Transients on the British 132kV Grid (Ref. G/T 264). By L. Gosland, B.Sc., M.I.E.E., and J. S. Vosper, B.Sc. (Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association. Price 10s., postage 4d.—The results given in this report have been obtained by means of the E.R.A.'s multi-frequency network analyser and so far three substations have been considered. For each transient the rate of rise of voltage and the amplitude factor have been determined. An indication is given of the probable effect of the addition of the proposed 275kV network. A survey, as yet incomplete, of the characteristics of the British 132kV network suggests that rates of rise of voltage up to $7{\cdot}5kV/\mu$ sec at amplitude factors up to 1·7 can exist at up to about 400MVA. These rates of rise are associated entirely with reactor circuit-breakers. Rates of rise of voltage of the order of $4kV/\mu$ sec exist up to about 50 per cent of the total short-circuit MVA on any one busbar. Future developments may lead to such rates of rise at up to 80 per cent of the total MVA. Amplitude factors in such cases are variable, ranging in the cases covered from about 1·2 to 1·8.

The Design of Capacitor-Transformers (Ref. Q/T 122). By S. Silbermann. The British Electrical and Allied Industries Research Association. Price 24s., postage 4d.—In an earlier report, Ref. Q/T 104, the design of capacitor-transformers for the special case of taking comparatively small amounts of power from high-voltage lines was investigated. This study, however, is not wide enough and does not cover instrument transformers where great accuracy in voltage drop, in phase angle difference between the primary and secondary voltages and in the influence of a deviation in the supply frequency are required. The present report deals with the theory of such capacitor-transformers and with the application of the developed formulæ to the practical design.

Electrical Soil Warming for Salad Crops (Ref. W/T 24). By A. E. Canham, M.Sc. (Eng.). The British Electrical and Allied Industries Research Association. Price 9s., postage 3d.—A description is given of a further investigation of the simplified electrically heated hotbed to determine the optimum dosage and planting date. Recommendations are made for its use both by amateur gardeners and commercial growers. The report recommends that, for soil warmed hotbeds on a commercial scale, the dosages of 40–45W-hours per square foot per day (50–55W in the north) originally recommended should be used unless a sufficiently favourable market justifies an increased running cost, when 70–80W-hours per square foot per day can be used. For amateur purposes the latter dosage may be found worth while.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX

Fri. to Mon., Sept. 19th to 22nd.—The Hayes, Swanwick, Derbyshire, Conference on "Information Service: Theory and Practice."

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Sept. 1st.—LEEDS BRANCH: Great Northern Hotel, Leeds, "Application of Aluminium in the Construction of Cables," J. W. Fall and J. W. Robertshaw, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, "The Work of the Association," G. Davidson, 8 p.m.

Tues., Sept. 2nd.—Windsor Castle Hotel, 134, King Street, Hammersmith, W.6, "The Isolation of Vibration and Noise from Electrical and Mechanical Machinery," R. B. Gray, 7.30 p.m.

Wed., Sept. 3rd.—N. LONDON BRANCH: Three Jolly Butchers Hotel, Wood Green, N.22, "Air Conditioning and Modern Methods of Insulating Buildings," A. C. Mackadam, 8.15 p.m.

Thurs., Sept. 4th.—S. LONDON BRANCH: Cafe Royal, North End, Croydon, "Oil Burners and Panel Heating," E. H. Bailey, 8 p.m.

Fri., Sept. 5th.—CREWE BRANCH: Crewe Arms Hotel, Crewe, "Ethical Implications of Science," J. Levitt, 7.30 p.m.——LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, Dale Street, Liverpool, 2, Chairman's Address, L. Harper, 7.30 p.m.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Wed. to Wed., Sept. 3rd to 10th.—Annual Meeting in Belfast.

ENGINEERS' GUILD

Thurs., Sept. 25th.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, Annual General Meeting, 6 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., Sept. 4th.—SOUTH YORKSHIRE BRANCH: Evening visit to Ladybower Dam, 7.15 p.m.

Thurs., Sept. 11th.—NEWCASTLE UPON TYNE BRANCH: Roadway House, Newcastle upon Tyne, "Liquid Fuel Firing," Alan Moore, 7.30 p.m.

Sat., Sept. 13th.—DUNDEE BRANCH: Works visit to Expanded Rubber Company, 2.15 p.m.

Mon., Sept. 15th.—LIVERPOOL AND N. WALES BRANCH: Radiant House, Bold Street, Liverpool. "Amenities in Industry," H. S. Crump, 7.15 p.m.

INDUSTRIAL WELFARE SOCIETY

Thurs. to Sat., Sept. 4th to 13th.—Keble College, Oxford, Third Annual Conference for Apprentices, Theme: "The Approach to Industrial Responsibility."

INSTITUTE OF FUEL

Tues. and Wed., Oct. 28th and 29th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Conference, "A Special Study of Ash and Clinker in Industry."

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Sept. 9th.—MIDLANDS CENTRE: Crown Inn, Broad Street, Birmingham, "Some Factors Influencing the Choice of a Crankcase Lubricating Oil," A. Towle, 7.30 p.m.

Wed., Oct. 1st.—Royal Society of Arts, John Adam Street, London, W.C.2, Annual General Meeting, 6.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Tues. to Thurs., Sept. 23rd to 25th.—Imperial College of Science and Technology, Prince Consort Road, South Kensington, London, S.W.7, Symposium on Mineral Dressing.

INTERNATIONAL MACHINE TOOL EXHIBITION

Wed. to Sat., Sept. 17th to Oct. 4th.—Olympia, London.

IRON AND STEEL INSTITUTE

Tues. to Thurs., Oct. 7th to 9th.—Special meeting in Swansea.